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DEBRIS/ICE/TPS ASSESSMENT AND SHUTTLE MISSION STS-32R PHOTOGRAPHIC ANALYSIS

1990 January 9,

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1990 Approved: 16, March

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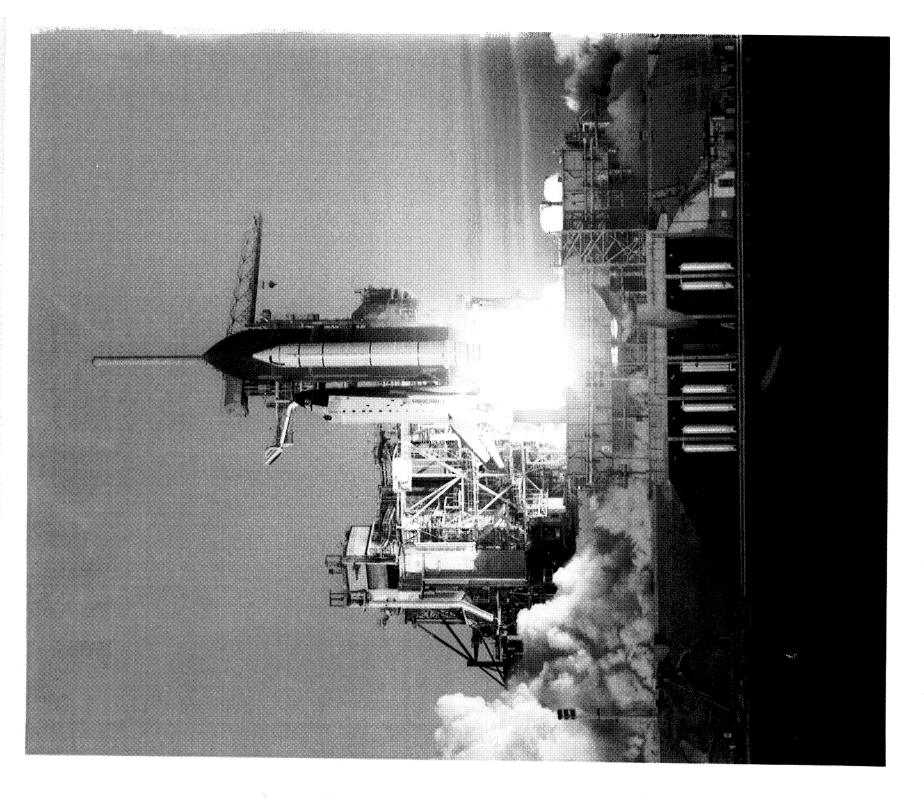
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Summary	KSC Ice/Frost/Debris Team	Pre-Test Briefing Pre-Launch SSV/Pad Debris	Scrub	ce/Frost Inspection	Orbiter	cket Boost	External Tank		in	Launch	ost		ocke		•	Pad Debris	Launch Crew Commen	Film Review Summary/Problem	Film	t Film Data Rev	Landing Film and Data Revi	SRB Post Flight/Retrieval	SRB De	SRB Debris	red SRB	Orbiter Post Landing Debris	Debris Sample Lab Reports	Post Launch Anomalies .	Launch Pad Inspecti	Review	rieval	Orbiter Post landing
1.0	2.0	3.0	4.0	•	•	•	•	4.5	•	•	•	•	•	5.4	•	0.9	•	7.0	•	•	•	•	•	8.2	•	0.6	0.0	•	•	•	1.3	•

#### FORWARD

The Debris Team is continuing its effort to develop and implement measures to control damage from debris in the Shuttle operational environment and to make the control measures a part of routine processing and operations.



Launch of Shuttle Mission STS-32R on 1/9/90 at 7:35 a.m. EST 1

ORIGINAL PAGE COLOR PHOTOGRAPH

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#### Summary 1.0

is and Photo Analysis Team activities for Mission STS-32R in with the pre-launch debris inspection of the launch pad Shuttle vehicle on 7 January 1990. No major anomalies were brived on OV-102 Columbia, BIO35, or ET-32. Although the ESP been removed, a red GSE cover #RK395-40063-71 was still tched to SSME #1 at the 6 o'clock position between hatbands was dispositioned with MRB approval to use-as-is. Minor facility discrepancies, which included loose MLP deck bolts and loose olts and loose were corrected the No tape the removed prior to cryoload. the anomalies or loose ablator/cork were observed with tion of a 4"x2" piece of duct tape on the aft side SRB upper strut fairing. A Problem Report on the Team act...
debris inspection
reary 1990. No major s
reary 1900. No major s items in the holddown post haunch area, to cryo loading the vehicle. Was blece (
strut f The cover and #9. attached Debris debris prior had

y 1 inch wide by inch from black tiles at a position 4 rows aft of the wing leading edge RCC panel #14. Condensate, but no ice or frost, was present on all acreage areas of the External Tank. There were no unacceptable ET TPS anomalies. Seven Ice/Frost console anomalies were docu-2 inch icicles icicles formed vent and was removed by the Ice Inspection Team during 32RV-0229, The hydrogen NSTS documented Inspection. icicles, on the diameter, and the he next launch attempt. The hy detected no significant hydrogen designed launch per the LCC IPR install a north GOX vent duct. The icic diverters had not been installed WAS Four ρX 4 inch and one in o PR RWNG-2-09-3199, was face during the Ice Н long inch documented specially approximately period. t t ght wing lower surface during tl GSE tile shim measuring 4 inches inches thick protruded approximat removed by the Ice Team using the specialet. A Problem Report was initiated diverters prior to the next launch aumbilical leak sensor detected no signi Н 8 inches long by the pad modification anomalies. Seven Ice/Frost and found acceptable for l One of these anomalies, three involved the formation of on the end of the north Orbiter tile anomaly, on the end of the because the hydro largest measuring cryo load and T-3 hour hold. inches during rightmented orange 08303. 0:030

the tank acreage. A small amount of ice/frost formed on the tack port closeout on the ET aft dome siphon manhole. In lition to the ice/frost, a small amount of vapor was visible intains from this area. five hours after the scrub acceptable scrubbed due to RTLS weather violations. SRB OF was the Orbiter condition TPS damage, such as divots to The launch was scrubbed due to RIII drain inspection was performed This There was no damage from this area. addition to emanating f NSTS-08303. decision.

alldetected had formed in The vehicle .... scrub/turnaround. No new Orbiter or ... during the Ice Inspection. Condensate was present arreage areas of the External Tank. Minor frost had formed acreage areas on both the LO2 and LH2 intertank flanges. several areas on both the aft dome apex. A SLA vent close

0 of Hard support ET/Orbiter exhibited duct hydro diverters from Pad B were or to cryoload and prevented icicle documented ost accumulation. There were the umbilicals or any evidence the LCC and NSTS-08303. TS-0063 inch. Pk .. al to fly-as-is. well within the data ations of frost on the LO2 F The LH2 ET/Orbiter umbilical anomalies were in the LO2 feedline bellows accumulations of frost on the Lo dispositioned with MRB approval 3/8 protruding GOX vent duct hydro a Pad A prior to cryolcelve Ice/Frost console acceptable for launch per Light are typical. The Line.

han average ice/frost condition was was diameter ice Twelve present vapors launch, the ET leakage. The installed on ice formation. than in formation. taken and umbilical found brackets. Was greater unusual

39A was performed after screed (4"x3-5/8"x1/2" the FSS in the box car had 0 рe Orbiter Q-felt lifted. No signs indicative of stud hang-up were visible. No fragments from HDP debris containers were found. The GH2 vent line had latched properly. Overall there was very little damage Was on tile V070oost shim material was intact, but he from the shoe sidewall. The shim outboard corner could plugs were recovered, no significant flight hardware or material was found. Launch damage to the holddown posts minimal. South holddown post shim material was intact, but Although 3 Orbiter flight hardware shoe was completely debonded and area. The screed was an unrestricted 364 repair 197004-069, which is located in the forward, outbo A post launch debris inspection of Pad 39A was launch. A large piece of white tile screed maximum thickness) was found west of the FSS the RH outboard elevon upper surface. Althoug plugs were recovered, no significant material was formand. debonded significantly Holddown post #2 shoe w the launch pad. t o

affected the plungers and the holddown post studs were omitted for flight in an attempt to eliminate stud hang-ups. However, change caused a considerable amount of debris to fall from rehicle during liftoff. A total of seventeen frangible nut flight hardware was observedx that would have affected the success of the mission. However, the white tile screed repair found at the pad after launch was visible falling from the RH outboard elevon just before the vehicle completed the roll outboard elevon just before the vehicle completed the roll maneuver. Frangible links between the Debris Containment System (DCS) plungers and the holddown post studs were omitted for lost at causing any visible tile damage. Numerous from the vehicle were visible during ascent. damage. Numerous instafoam analyzed as part wing the from HDP OH chunks were observed falling from GSE tile shim discovered by prior damage shim discovered by inspection fell from the RH any visible tile damage. identified as ice/frost particles licals, RCS paper covers, and and 100 SRB plumes video items were analy Lew. No major vehicle covers, ACS paper covers, skirts. More than Tank. the External the in visible from the A total of 118 film and vide the post launch data review. fragments aft The orange ice ET/Orbiter umbilicals, particles from the SRB #5, #7, and #8. The or Team during the scrub liftoff without caus: separation slag were and NSI cartridge #5, #7, and #8. The of debris have been vehicle propellant pieces Most ha this this the

and οĘ recorded diameter largest divots, These cameras revealed several divots the forward part ole in the divo n line. Two divot divot from bipod ramps The divots measuring 12-14 inches in the intertank acreage between the bartank-to-LH2 tank flange. A third was centered between the bipod raintertank-to-LH2 tank flange. The inches wide, surrounded the forward in the ET/ORB umbilicals noted missing . Stringers were visible in greater than the isochem line. repair, were also noted missi tank acreage in the spray abort areas. in diameter was centered bet into the intertank-to-LHZ measuring 28 inches wide, surribipod ramp. Stringers wer int on the intertank the intertank-to-LH2 35mm and two 16mm cameras and ET separation. These c acreage. Two divots Ø ing a depth which was a 35mm and two apparent above indicating extended LH oŧ inches Were

moisture seal was debonded on the leading edge at 230 degrees (3.5" long by 1" deep) and 280 degrees (3" long by 1.25" deep). Portions of the phenolic plates on both the RH and LH +Z RSS antennas were missing. The PDL pour on the aft side of the RH IEA was missing and the bolt head underneath was sooted. The RH +Y IEA end cover aft outhoard corner. was missing near the aft side of the RH upper strut. HDP #1, #2, #3, #7, and #8 plungers were not seated and the remaining plungers were seated on offset spherical washers. The percentage of frangible nut/NSI debris (not including frangible nut halves) retained by the DCS's was measured to be: total undamaged. divot of MSA-2 ΑĒ Ø exhibited Hanger The Solid Rocket Boosters were inspected at Hangeretrieval. Both forward skirts and frustums exhibit of 29 debonds. The LH frustum lost a 2-inch divot of near the 275 ring. All field joint closeouts were The LH aft segment stiffener/stiffener factory

32%	70%	918	59%
	HDP #6		
45%	53%	35%	68%
*	HDP #2	#	*

nch is con-a potential i. S launch and during this unacceptable of DCS debris lost þe the vehicle. Team to unnecessary hazard to sidered by the quantity

The Orbiter TPS sustained a had a major dimension of one Is missions of similar configuration, the number of hits lower surface is average. Also, based on the severity of as indicated by surface area and depth this first and the severity of the se A post landing inspection of OV-102 was performed on Runway 22 and in the Mate/Demate Device. The Orbiter TPS sustained a total of 120 hits, of which 15 had a major dimension of one inch or greater. The Orbiter lower surface had a total of 111 hits, of which 13 had a major dimension of one inch or greater. Based on these numbers and comparison to statistics from EO-1 bolt's ordnance scratched better than average. Although the Orbiter was found to be excellent condition, it was discovered during pyro removal the RH Y-Y stop-bolt from the forward attach point EO-1 bo centering mechanism was compressed and bent. The EO-1 ordn area and depth, this .... to have been found also Were spring housings previous missions of on the lower surface damage

due to contact with both the LH and RH bulkhead pyro connector backshells. The damaged assembly was removed for analysis to determine the cause for these anomalies.

Launch Anomalies were observed during this A total of 20 Post mission assessment.

### TEAM ACTIVITIES ICE/FROST/DEBRIS KSC 2.0

MAF, ASA JSC, MMMSS -NASA - DOWNEY, ITI - UTAH KSC, NASA MSFC, SPC, RI - DOWNE: MTI BPC, LSOC USBI NASA Composition: Team

Activities: Team

Debris Inspection Pad Prelaunch 7

Baseline potential evaluate Identify and Objective:

existing sonrces debris material/sources. debris and debris sources

launches.

exhaust from previous MLP

flame vehicle SRB Shuttle and ORB FSS, deck, holes,

Areas:

surfaces external

engineering An ı day \$00000.030 OMRSD Requirements: Time:

pad launch identify/resolve potential shall shuttle and team inspection the inspect debris t 0

þ shall prelaunch vehicle/pad configuration The debris sources.

documented/photographed. S6444 OMI Documents:

recommend and Generate PR's Report:

corrective actions

to pad managers

Launch Countdown Firing Room 2 5

g accumulation ice/frost Evaluate Objective:

any and/or vehicle shuttle

OTV debris utilizing observed

cameras.

vehicle Shuttle deck, Areas:

FSS, Shu surfaces external

9 hour Н to Launch + 6 hours Н Time:

Monitor drainback S00FB0.005 propellant OMRSD Requirements:

surfaces and record ET TPS tape video

through loading during

prepressurization. OMI

Launch Director, Generate IPR's. S6444 Shuttle Documents Report:

managers.

and

#### Debris Inspection and Ice/Frost TPS 3)

Objective:

any or vehicle ET, safety of flight evaluate anomaly which may be any ORB, formation material. other possible facility and and evaluate Identify any ice . debris source or TPS potential Evaluate concern. anomalv debris

Areas:

Shuttle vehicle MLP deck, FSS, Shexternal surfaces

Time:

(during) hours

Requirements:

shuttle walkdown tiles Evaluate, for water for ice/frost, formation engineering observed by after TPS hour BIH) compartment required during During to verify inspect ET inspection team shall and photograph all During shuttle w anomalies engine compartment (externally) i ce y 2 An areas which cannot be temperatures. shuttle orbiter aft condensation and/or ı inspection in or between aft walkdown, S00000.020 and debris cryo propellant OTV system. scan is the document, anomalies. inspect shuttle surface inspect shuttle debris OMRSD An IR

> Documents: Report:

IPR'S Launch Director generate S6444 management; Briefing to NTD, OMI 20002 Shuttle OMI

#### Inspection Pad Debris Post Launch 4

Objectives:

Areas:

debris that the Shuttle launch. and identify damaged vehicle during could have Locate

inaccessible and t t the from Playalinda to Complex and of trenches exhaust holes οŧ surfaces walkdown overview of trenches, FSS, pad slopes, extension c perimeter fence, deck, flame oches, FSS, F aerial trenches, beach MLP 40,

Time:

safing, (after pad + 3 hours washdown) Launch before areas.

engineering An S00000.010 OMRSD Requirements:

identify any lost and systems hardware launch pad/area team shall inspection ground perform a post inspection to or debris flight

configuration hours; shall be documented/photographed and verbal sources. at L+8 LTD II a debris launch pad/area 86444 ţ Level S0007, OMI report resultant PR's briefing generate Initial post and OMI

Documents

Report:

Review Launch Data Objective:

aircraft t 0 speed films from damage Identify and photographs range trackers, onboard cameras determine possible launch of high vehicle. and debris Detailed review tapes, cameras, vehicle flight debris video the

days 9 + debris sources. - An S00000.011 + Launch OMRSD Requirements: Time:

launch engineering the shall be identify or ground system Id affect orbiter ţ engineering or future as possible to damage analysis identify any debris dan space shuttle vehicle. flight operations could on all and flight vehicle soon film review damage that performed as film

launches Documents

Report:

day Daily reports to Level II Mission on L+1 generate PR's. starting through landing; Management Team S6444

SRB Post Flight/Retrieval Inspection 6

debris SRB Evaluate potential Objective:

landing correlated Orbiter post Data will be observed sources. with

TPS damage.

Areas:

Time:

external surfaces (Hangar AF, CCAFS) SRB

(after on-dock, Launch

engineering An h + 24 hours (a e hydrolasing) S00000.013 - 3 before OMRSD Requirements

inspection team shall inspection. with launch Any any coordinated documented, perform a post retrieval of the SRB's to identify inspection launch debris. of the post area debris and damage photographed results shuttle/pad caused by anomalies debris

OMI Documents:

B8001 Report:

report Daily reports to Level II Mission Management Team. Preliminary repo Evaluation SRB Disassembly Generate PR's

### Landing Debris Damage Assessment Orbiter Post

Objective:

debri source οŧ areas o due to possible, time of occurrence. and evaluate TPS damage to Orbiter and correlate, if Identify and damage to and

are inspected debris. on runway, runways for debris and sources of runways surfaces, vehicle safing Additionally, Orbiter TPS

> Areas: Time:

towing before After

engineering An ı S00000.040 OMRSD Requirements:

debris inspection team shall perform a prelanding runway inspection to identify, document, and collect debris that could collect

and any facility anomalies cannot be removed/corrected Team shall be documented a Runway damage. in orbiter result debris which

and photographed; the proper management by the

authority shall be notified and corrective actions taken. Requirements:

An engineering ı S00000.050 OMRSD

runway team shall and inspection to identify ar resolve potential debris inspection team perform a post inspection to i debris

sources that may have caused vehicle damage but

during the pre-launch on. Obtain photowere not present or were flight any or runway inspection. Obtain graphic documentation of a debris, debris sources, or identified not

hardware that may have been lost landing. u o

An engineering inspection team shall map, orbiter TPS damage and ı OMRSD S00000.060 sources. document, related debris debris Requirements:

S00000.012 OMRSD Requirements:

shall damage caused by launch debris anomalies must be documented/ perform a post landing inspection of the orbiter vehicle to identify engineering inspection team - An damage debris any

Any

Requirements:

photographed and coordinated with the results of the post launch shuttle/pad area debris inspection.

OMRSD V09AJO.095 - An engineering debris inspection team shall perform temperature measurements of RCC Nose Cap and RCC RH Wing Leading Edge Panels 9 and 17.

OMI S0026, OMI S0027, OMI S0028 Briefing to NASA Convoy Commander and generate PR's. Preliminary report to Level II on the day of landing followed by a preliminary update the next day.

Documents: Report: Level II report

8

Objective:

Compile and correlate data from all inspections and analyses. Results of the debris assessment, along with recommendations for corrective actions, are presented directly to Level II via SIR and PRCB. Paper copy of complete report follows in 3 to 4 weeks. (Ref NASA Technical Memorandum series).

### 3.0 PRE-TEST BRIEFING

activities was the following The Ice/Frost/Debris Team briefing for launch sconducted on 7 January 1990 at 0800 hours with key personnel present:

ບໍ	Stevenson	NASA	1	KSC	•
ថ	Katnik	NASA	ı	KSC	Lead, Ice/Debris Assess Team ET Mech/TPS, Ice/Debris
					Assessment, STI
Ω •	Higginbotham	NASA	į	KSC	STI, Debris Assessment
m m	Speece	NASA	ı	KSC	ET Processing, Ice Assess
m m	Bowen	NASA	i	KSC	ET Processing, "SURFICE"
ь	Rivera	NASA	I	KSC	ET Processing, Debris Assess
Ą.	Oliu	NASA	ı	KSC	ris Asse
Σ	Bassignani	NASA	ı	KSC	A)
<u>м</u>	Davis	NASA	į	KSC	sessm
봈.	Tenbusch	NASA	ı	KSC	"SURFICE", Debris Assess
<b>ب</b>	Hoffman	LSOC	ı	SPC	ET Processing, Ice Assess
Σ	Xoung	LSOC	ı	SPC	
Σ	Jaime	LSOC	ı	SPC	Ice
ь	Blue	LSOC	ı	SPC	ET Processing, Ice Assess
Ēų.	Huneidi	NASA	ı	MSFC	TPS & Ice Assessment
Ď.	Andrews	NASA	ł	MSFC	Debris Assessment
7	Byrns.	NASA	ı	JSC	Level II Integration
ပ်	Gray	MMC	1	MAF	ET TPS & Materials Design
ა	Copsey	MMC	ı	MAF	/Cert
<u>ь</u>	Harner	MMC	ı	KSC	ET Processing, LSS
р	McClymonds	RI	ı	Downey	Debris Assess, LVL II Integ
H	Thorson	RI	i	LSS	ation
#	Novak	USBI	Î	PSE	SRB Processing
Ħ.	Huppi	MTI	1	Utah	SRM Plant Representative
М.	Parsons	MTI	1	LSS	SRM Processing

team activities, f data, and wrote of data, in various evaluation These personnel participated in assisted in the collection and evareports contained in this document.

# 3.1 PRE-LAUNCH SSV/PAD DEBRIS INSPECTION

Shuttle vehicle 1200 hours. The ?-3 also included the (9th flight), ET-32 ohs were was conducted on 7 January 1990 from 0930 - 1200 detailed walkdown of Launch Pad 39A and MLP-3 also primary flight elements OV-102 Columbia (9th fli primary flight elements OV-102 Columbia (9th 1 (LWT-25), and BI035. Documentary photographs facility anomalies, potential sources of veh debris, and new vehicle configurations. The pre-launch debris inspection of the pad and was conducted on 7 January 1990 from 0930 - 1

no major vehicle anomalies. Although the ESP had d, a red GSE cover #RK395-40063-71 was still SSME #1 at the 6 o'clock position between hatbands The RH SRB upper strut prior to cryoload. The RH S LH side was not. A piece side of the -Y upper str The cover was removed prior had been painted, the LH si adhered to the aft no major removed, t t and #9. BSM covers attached fairing.

the vehicle by three velcro strap assemblies. hute cord attached to these assemblies enable atus to be quickly removed from the vehicle leakage consists quickly removed from the vehicle the hydrogen sensor is intended to from the ET/ORB LH2 umbilical interiace area cryoload/launch of STS-28R, a temporary hydrogen detector installed at the ET/ORB LH2 umbilical until a permanent sencan be designed and installed. The temporary detector consite two tygon tubes that run from the LH2 umbilical area to hazardous gas detection equipment located on the FSS. The tuwere attached to the vehicle by three veloro strap assemblies ena without causing TPS damage. The hydrogen sensor is intendecremain in place during cryo loading and be removed by the Inspection Team during the T-3 hour hold. e continued concern over potential hydrogen ET/ORB LH2 umbilical interface area duri of parachute re apparatus the

This inspection of the of the I the deck bolts. This ins adjacent to suppression water pipe, and in the deck plate east TSM. A nut and washers were missing from a U-bolt the south side of the LO2 TSM. the SRB exhaust holes A recurring problem is loose MLP revealed loose deck bolts on the vehicle, between the SRB exhaust

the Portable Purge Unit tether wire retaining north MLP access door east stairs. end attached near t SSME exhaust hole. connector west side adjacent to the Portabland on the MLP east side near the electrical sealed. theand one A grounding strap was loose with only one south side of the LH2 TSM adjacent to the entire pipe spout, along with its cap and screw, west of the LH SRB was loose. The had been closed on a rope and was not sea. discrepancies included a missing the MLP connection point grounding on covers

Instafoam Red tape was attached to the southwest side of holddown post #1. Debris a plastic cap were visible in the haunch area of HDP Masking and silver duct tape near HDP #5 was loose. Instaf

Pad B Hydro r to dee from running installed. This b thePad A. nt icicle formation on in incorporated on Pacer and condensate from had not been installed ctural features to prevent vent ducts had not been rters, which prevent water duct ends and freezing, ha res to prevent had not been been approved by PR - MRB. GOX vent diverters, Structural

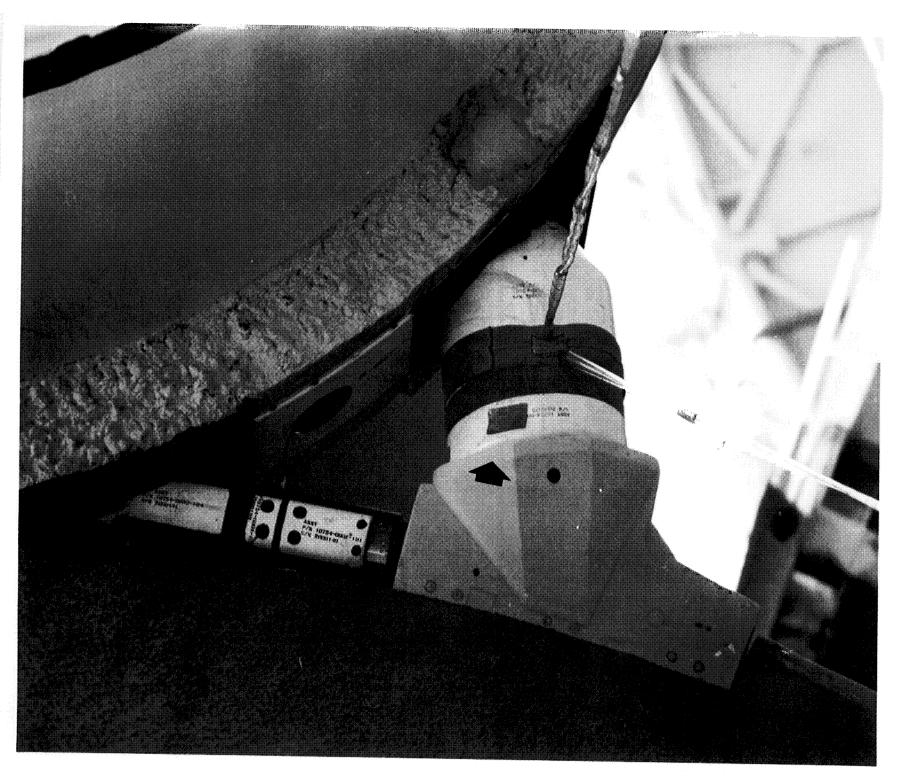
almost complete at discrepancies were leader for resolu-Cleanup of the MLP deck and pad surface was the time of the inspection. The facility worked real-time or transferred to the pad tion prior to vehicle tanking. 14



to cryoload removed prior was #1 SSME on cover Red GSE

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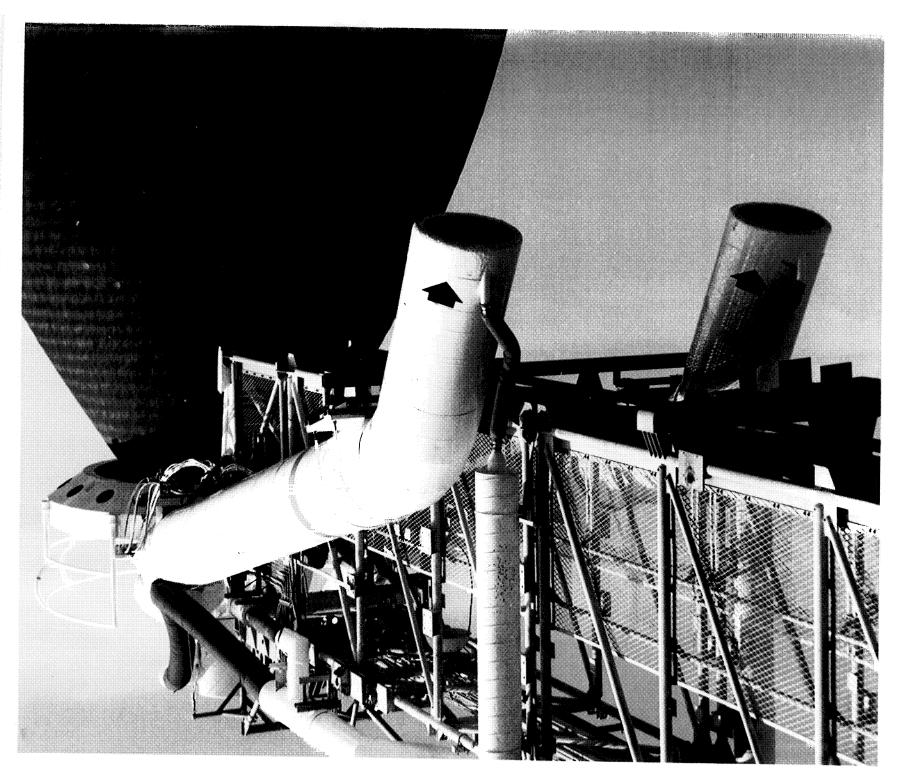
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strut 4-inch piece of duct tape of the aft side of the LH upper fine fairing remained for flight per MRB approval

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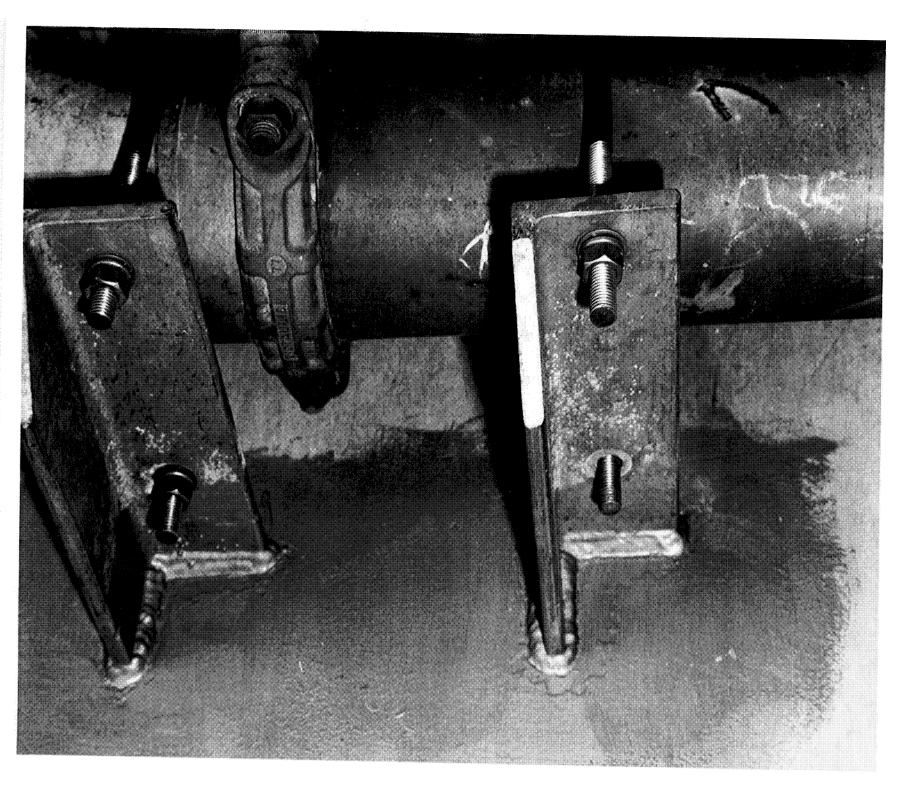
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Absence of hydro diverters, which had not been installed on the GOX vent ducts, eventually caused the formation of icicles.

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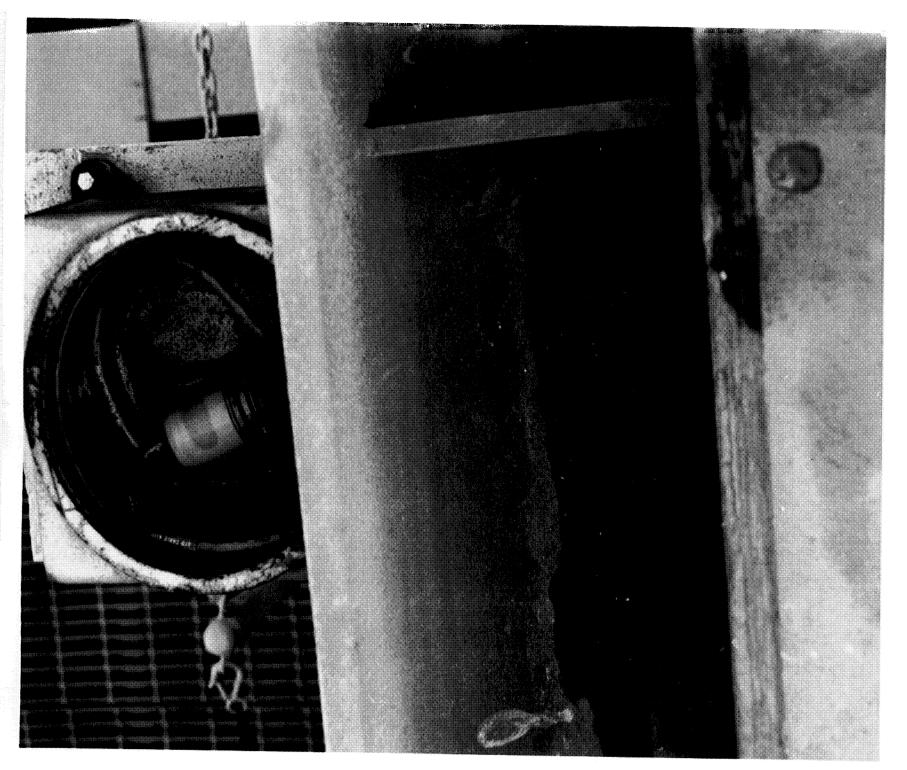
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SSME exhaust on the sound suppression pipe near the hole was missing a nut and washer 17 A U-bolt

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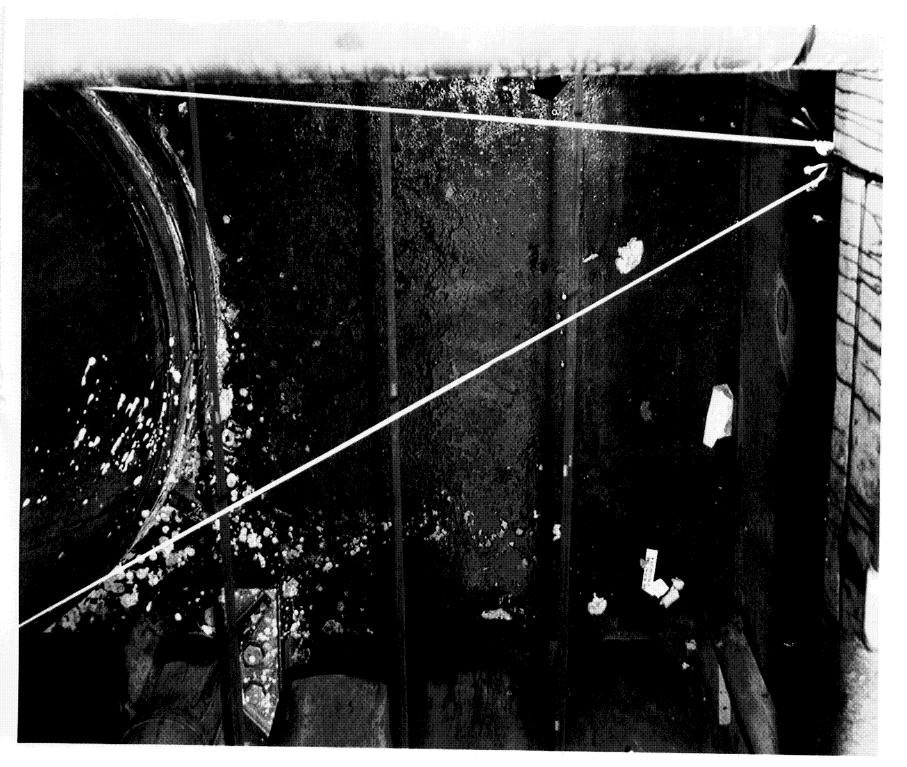
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electrical box on the MLP NW 18cover was missing from the

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	T	·8°		06-	4yn			



and foam overspray/trimmings in the HDP #6 haunch 19 Metal nut

ORIGINAL PAGE COLOR PHOTOGRAPH

*	T.	

#### 4.0 SCRUB

EST 0905 at scrubbed a violations LCC was weather STS-32R RILS for ţ countdown due 1990 The launch January

## 4.1 ICE/FROST INSPECTION

during the countdown. There Commit Criteria. vehicle from 0210 to 0510 hours T-3 hours in the countd cryoloaded were no violations of NSTS-08303 or the Launch the οĘ time January 1990 from 0210 the theοĘ weather conditions at at Inspection three hour built-in-hold Ice/Frost on 8 performed Ambient

Temperature: 68.1 F
Relative Humidity: 99.5 %
Wind Speed: 10.9 Knots
Wind Direction: 180 Degrees

obtain assesstemperature measurements for an overall thermal the vehicle, as shown in Figure 1 and 2. portable surface temp ment of the

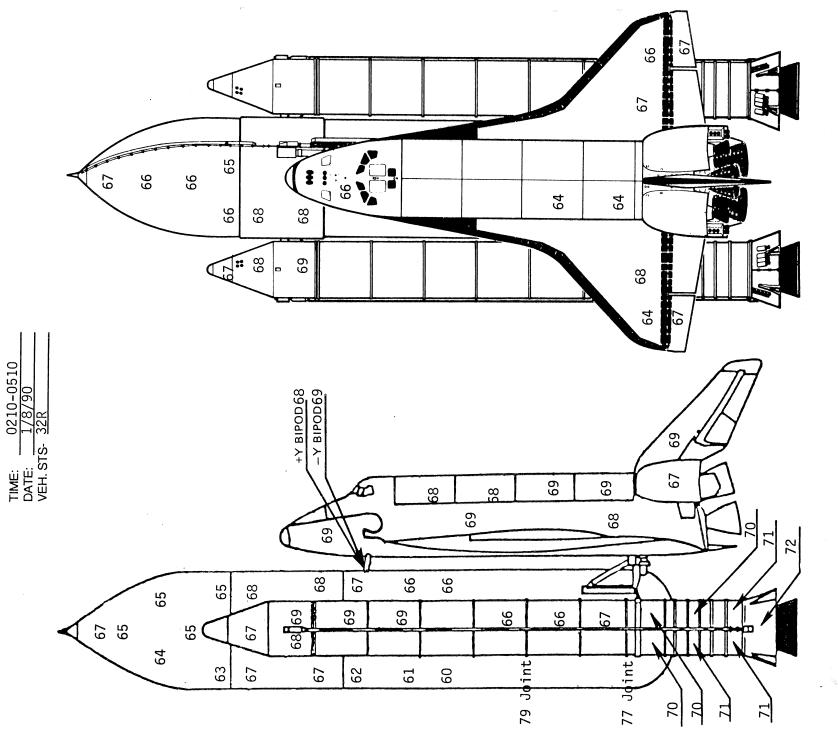
### 1.2 ORBITER OBSERVATIONS

average surface temperatures of the SSME engine mounted heat shields were measured at 66 degrees F for SSME #1, 66 degrees F for SSME #2, and 67 degrees F for SSME #3. SSME #1 had a small amount of ice at the nozzle to heatshield interface 6 o'clock position. Condensate, but no ice or frost, was present on all three heat shields. A prevailing wind from the content of a second of the content of the content of a prevailing wind from the content of a second of the content of the content of a prevailing wind from the content of t protruded average Orbiter shim measuring documented 4 overboard vapors into the engine bell nozzle. a position One Orbiter tile anomaly, PR RWNG-2-09-3199, was docuthe right wing lower surface. An orange GSE tile shim 4 inches long by 1 inch wide by 0.030 inches thick approximately 1 inch from the black tiles at a positiaft of the wing leading edge RCC panel #14. The average surface temperature was recorded as 64-70 degree average surface temperatures of the SSME engine mou oxygen

### 4.3 SRB OBSERVATIONS

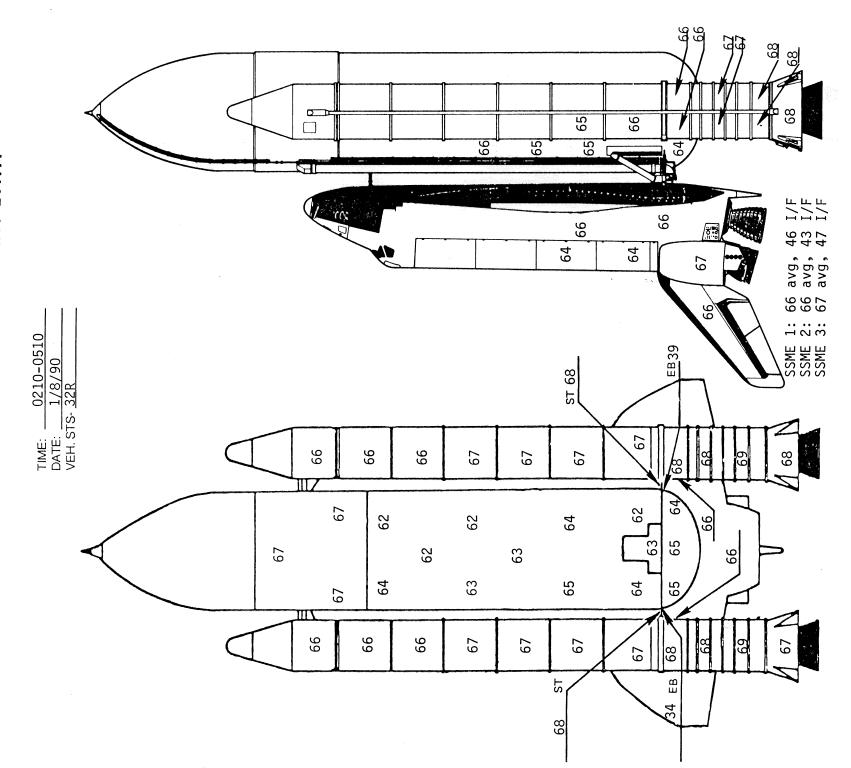
heaters ean Bulk Problem approval recorded with tween 66 to 69 de
field joint hea
Propellant Mean by 2-inch wide piece of duct RB upper strut fairing. A NY SRB Engineering with MRB atable inferdegrees F. scanner temperatures between area of the SRB fiel supplied by MTI was 64 use-as-is. The STI portable infrared and LH SRB case surface temperatures bett. Temperatures in the area of the SRI averaged 79 degrees F. The predicted the aft side of the -Y SRB upp Report was dispositioned by SRB No SRB anomalies or loose exception of a 4-inch long the aft side of the -Y SR (PMBT) Temperature

FIGURE 1. INFRA RED SCANNER SSV SUMMARY DATA



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2. INFRA RED SCANNER SSV SUMMARY DATA FIGURE



## 4.4 EXTERNAL TANK OBSERVATIONS

on 2300 and accumulation from 4, 3 ction computer program was run results tabulated in Figures in Figures ice ou with condensate st prediction and the result surfaces. program predicted acreage ice/frost hours TPS 0845

102 measured 102 the go ost, was present or hk. The IR scanner degrees F on the I on degrees F frost, tank. 62 65 and o£ or LH2 on the Intertank, temperature ice and condensate, but no (run on) lower LH2 tank. surface Intertank degrees average Acreage tank, and

There was no acreage ice trickled down condensate dome. οĘ amount the aft greater-than-average 12 tank and ran off th LH2 tank frost

strut truts strut the  $\operatorname{The}$ fittings outboard to rest of the fitting. ' covered by ice. EB pin hole with condensate on the lower covered the and were not Ice/Frost were dry

cracked ble per acceptable interface had . S condition tank LH2 to LH This longeron formed. had **⊁** TPS in the ice/frost NSTS-08303. TPS and The

bellows These conditions feedline 102 support brackets. a11 in present Were acceptable per NSTS-08303. feedline i.ce οĘ the LO2 amounts Normal in

A normal in the LH2 recirculation line bellows. feedline bellows. the LH2 There was very little ice in amount of ice had formed in t

nts and vapors umbilical The largest the purge vents out slightly ET/ORB umbi evidence of leakage. unusual accumulations. The the aft side of ed on the purge v but ost fingers had formed on the aft sy was occurring. There were no the umbilicals nor any and any The LO2 i Ce exhibited less frost. ice/frost οŧ accumulation was lo accumulations exhibited typical (light) ET/ORB umbilical venting from than normal umbilical. LH2 normal The

sign around the GUCP, but there was no frost had formed of leakage. Minor

The tumble valve cover was properly installed and intact

removed tubing was sensor tygon ET/ORB hydrogen detection the vehicle. t 0 with no damage The

οŧ consists Ice/Frost Team observation anomalies items: OTV recorded οĘ summary  $_{
m The}$ 

icicles 1 on IPR remaining documented long All 2-inch GMT 09:11. was and one and duct a t 4-inch vent du fell 4-inch icicle three north GOX 001 recorded of the One 4-i end Anomaly on the

V., (*)		$\bigvee$			06/	TE:1/8	AIT 0-T		06/4/1	[ ]								qn	r Seri	Veather	TLS V	H 40	00S	:15		A26 - 212
06			(OLZ)			5326	ILL TIME			E: 2302			0, -		AST FILL	3 1823 1823	•	OM נורר. וררם OMM		¥6£	44	3 WLP	98018	882	32	RATIBRO
850		IK STR 13	AT SHJ						INAT SH		L	10 852	022 AT2	NAT 50	l n		0 k2 OT	OKE ATZ	NNAT 50	1		i	NOITIONS	l		
ITAR 3	CONE RATE IN/HI	SOFI SOFI OF	KNTS VEL LOCAL	моіз	- 1	BTAR	COND RATE AH\NI	SOFI TEMP 90	VEL VEL LOCAL	REGION	ICE RATE IN/HR	COND RATE RH\NI	SOF1 op	LOCAL VEL KNTS	RECION	ICE RATE IN/HR	COND RATE IN/HR	SOFI TEMP 9	LOCAL VEL KNTS	BECION	DEG DIB MIND	KN18 AEF MIND	ot DEM	HUM. *	TEMP.	LOCAL
2 - 522	0023	06.49	89.71	I	I 8	811.	6¥00	88.66	91.4	II	£282.	0300.	04.19	79.7	II	5845	6200.	98.49	79.7	II	203	13	£6.78	06	6.07	2300
1 7.1283	002	56.35	96.4	I	II Z	1437	. 0052	92.78	₽0.6	II	12124	1900.	gg:09	80.7	II	26432	1600.	₽7.E8	80.7	II	861	12	38.79	76	2.07	2315
erar_ e	900.	83.73	28.3	1	II S	7891	,005¢	0₹89	88.3	II	26₽2.¯	££00.	65.13	92.8	II	6772.	2800.	6I. <b>Þ</b> 9	92.8	II	961	ÞΙ	38.79	86	6.69	2330
3881 - 8	. 0053	08.93	₽6°₽	1	11 2	124	₽900;	99. 73	94.3	II	8922.	6300.	28.09	<u>79.7</u>	II	6832.	££00.	18.69	79.7	II	193	11	98.79	<b>₽</b> 6	3.69	2345
0917 3	9900	77.73	04.8		11  1	841.	9000	92.83	08.8	II	£693 <u>.</u>	3300.	<b>₽₽</b> , I 8	38.8	II	6162	₽€00.	60. <sub>P</sub> 9	<b>68.8</b>	II	061	12	87.78	96	2.69	2400
126	0023	06.33	96.4	7	II 8	30 <del>1</del> I .	₽900.	18.93	₽0.6	II	0802.	₱900	81.09	80.7	II	8682	₽£00°.	88.89	80.7	II	981	12	36.79	96	1.69	9100
3660	1900.	83.53	08.8		II	1211.	2500.	09.43	02.₽	II	6891	6300.	SP.83	06.3	. 11	6661.	₽£00.	71.28	06.3	II	981	OT	\$9.78	46	<b>3.89</b>	0030
8660.	1900.	33.63	08.8	E	II	6111	.0053	99.49	4.20	II	4891	0023	6E.83	06.3	II	8661	3500.	61.29	06.3	II	188	OT	87.73	86	8.89	9700
0711.	6600.	. <b>6₽</b> . <b>3</b> 3	81.1	Б	II	1308	9900	<b>∂₽. 9 ∂</b>	29.₽	11	1961.	9900	10.09	6₽.9	II	2525	9800.	<del>№</del> . E9	6₽·9	II	161	II	88.53	86	1.69	0100
ZZTT	₹002€	. 29 . 62	81.1	Đ	II ·	1315	9900	72. 93	29.₽	II	1961	0022	. 60 . 13	6¥.8	II	8977	9 £00 ·	<b>63. 6</b> 9	6≱. 9	II	961	II	89.89	86	2.69	9110
40FT.	9900	90.78	₱6:1	ð	II	1268	<b>4900</b>	£6.73	94.6	II	6622	4900	SI. 18	79.7	II	1292	7800.	01.49	79.7	II	<b>₽6</b> T	13	88.08	86	1.69	0810
8901	7900	99.43	08.	8	II	\$811 <u>-</u>	₹900	99.3	3 02.4	II	0241	₽\$00	₽₽·69	06.3	II	2083	. cos	ZI. E9	06.3	II	881	11	89.88	86	8.89	9710
1911.	₱900	<b>₽</b> £. gg	81.	Đ	II	1298	0022	08.8	3 29.1	II	1930	9900	.88.63	6ħ.8	II	2246	7800.	18.88	9 <b>6</b> £. 9	II	183	12	23.88	66	7.89	0020
9211.	0023	. 67.43	81.	Б	II	1260	0022	69 . 3	29 . 1	7 II	1880	0022	.08.6	6₽·9	II	2612	9800.	97.28	6 <sub>4</sub> .8	111	241	11	20.88	66	8.89	1215
0411.	7500	76.43	81.	ל	II	1275	9900	16.3	29.1	F II	0061	9800	. 53.6	€ 6₽.8	II	2215	. acoo.	96.29	6₽. 9	II	185	II	22.88	66	3.89	0820

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1083	0023	. 66. 83	81.4	II	1215	. ₽200	.76.43	29.₽	II	1822	0022	. 09.88	6₽. 9	II	2135	9800	01.28	9 6₽.8	II	183	Ιī	54.78	66	7.79	9 190
6111	0023	.09.40	81.1	II	1 252	9900	. 73. 33	29.4	II	1781	9500	81.69	6 <b>₽</b> .8	II	2185	9800	59. 29	<b>6₽</b> . 9	11	181	Ιī	26.78	66	2.89	0090
1219	₱900	12.68	4.56	II	1363	9900	. 61. 95	£0.3	II	₹5024	9900	. 63. 63	80.7	II	1152.	4800	67.29	80 . 7	II	221	12	27.78	66	0.89	9430
1234	3200 .	6₽.66	99.4	II	6781	9200	78.93	₽0.3	II	2045	9900	87.65	80.7	11	2362.	4800	10. 69	80.7	II	172	12	26.78	66	2.89	0230
1365	9900.	56.43	\$6.p	II	£251.	4900	. 18.73	9₽. G	II	1525	4900	60.53	79.7	11	2982	7800	₽ <b>3</b> °29	79.7	II	182	13	\$1.89	66	₽.89	9190
1280	3300.	81.95	93.4	II	8211	<b>4900</b>	60.73	₽0.3	II	6012	4900	74.09	80.7	II	8242.	7800.	79.69	80.7	II	981	12	23.89	66	8.89	0090
0511	₽ <b>2</b> 00.	76.43	81.4	II	2721.	9900	. <del>1</del> 6. 63	29 · Þ	II	0061	9900	£3.63	6₺.8	II	222.	9800.	86.29	6₽.8	II	₱ <b>6</b> I	II	22.89	66	g. 89	S <b>P</b> F0
1133	£300.	38.₽3	81.4	II	8921.	9900	18.33	29.p	II	0681.	3300.	14.63	6 <b>≯°</b> 9	II	3022.	9£00.	78.29	6Þ.8	II	183	11	SI.88	66	₽.89	0430
7121.	9900°	71.33	95.₽	II	1361.	9900	01.95	₽0.3	11	£202.	7300.	83.63	80.7	II	essz	8800.	77. 29	80.7	II	188	12	08.79	100	8.78	9110
8811.	₽ <b>9</b> 00.	64.93	81.4	II	£721.	9900	06.33	29 · Þ	II	868T_	9500.	19°69	6₽.9	II	-2214	7800.	96.29	6ħ.9	11	184	π	0ε.89	001	€.89	0070
₽660 <u>'</u>	2300.	74.63	08.8	II	9111.	₱900°	64.49	4.20	II	₽89 I .	3300.	₽6.83	06.3	II	3661.	<b>9</b> £00.	01.29	06.3	II	182	10	06.78	10,0	6.78	0342
7811.	₽900 .	89.43	93.4	II	62£1.	0026	29.62	₽0.3	II	1861.	9300.	70.63	80°4	II	9622.	7800.	28.39	80.7	II	184	12	04.78	100	₽.78	0330
0680	2900.	22.83	08.8	II	1011.	₱900	54.25	4.20	II	0991.	3300.	11.83	06.3	II	9791.	9800,	88.19	06.3	II	173	01	07. 78	100	7.78	0312
1542	9900°	<b>6</b> ₽.66	79°₽	II	1981.	9900	<b>₹.</b> 66	29.₽	II	1981.	<b>2</b> 200.	40.63	6Þ.3	II	2712.	9800.	₽ <b>5</b> .54	6¥.8	II	<b>94</b> T	π	28.79	66	1.89	0300
9101	2900.	88.63	08.8	II	E171.	₽900.	06. <sub>₽</sub> 2	4.20	II	£171.	₽900°	27.83	06.3	II	2202.	9800.	9 <b>Þ.</b> 29	06.3	II	6 <b>4</b> T	ot	21.89	66	₽.89	0542
ICE RATE IN/HR	COND RATE IN/HR	SOFI TEMP OF	LOCAL VEL KNTS	REGION	STAR AH\NI	COND RATE IN/HR	SOFI TEMP TO	LOCAL VEL KNTS	REGION	ICE RATE RH\NI	COND RATE IN/HR	SOFI TEMP OF	KNTS TOCAL	RECION	ICE RATE IN/HR	COND RATE IN/HR	SOFI TEMP OF	LOCAL VEL KNTS	REGION	DEG DIE MIND	KN18 AEC MIND	ot DEM	HUM. REL	TEMP.	LOCAL
8		IK STA 13	AAT SHJ				ELL ATS	H2 TANK	l		258 0	r 022 AT2	NATE	1	<u> </u>	01-2 OT	OTE ATZ	D2 TANK	1			SNOITIONS	)) ))		
6	06)		(OLZ)		2326 0122	ISH TIME:	II 7 TZA 7 IN 3 J 9 3 R		E: 530 WE: 532	IIT NWOQ. MIT JJIR				AST FILL		TIME: 2			A	Aq	WLP 3	032	BI	32	3 A3T18R0
I'V				06	E: 1/8/	IMIT 0-T TAQ		06/8/1	TAO		1			ningsand destring		crub	yer S		- RTLS		t	)0S	:T2		A26 -212

FIGURE 4. Ice/Frost Computer Predictions

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0+6-4/09	) <del>)</del>	1	T	1	1	<u> </u>	<u> </u>	<u> </u>	Т-	T	T	- 1	1	<u> </u>	1	1	1	<u> </u>			1	<u> </u>	1	<u> </u>	T .
		65.68					92.95					08.68	i				51.69			s	12		86	7.89	DVA
																							·		
1093	. seoo .	18.85	08.8	II	1222	₹900	.06.30	02.2	II	8181	. №00	\$0.08	06.8	II	2213.	9800	. 57 . 59	06.3	II	961	от	₽0.69	26	6.69	S#80
<b>1427</b>	9900	18.73	16.4	II	1291	<b>4900</b>	. 79.83	9 <b>₽.</b> ₫	II	8982	9500 .	18.18	79.7	II	2692	9800	. 97. 49	79.7	II	681	13	p0.69	26	6.69	0830
1182	₱900°	₽Z.88	81.1	II	1323	9900	69.95	29.₽	II	1961	5500 .	₽2.09	61.8	II	8722.	9800	. 99. 69	6 <b>þ</b> .9	II	181	11	£7.'88	86	€. 69	0872
1132	£200 ·	88.43	81.1	II	6921.	₱900	58.85	29.4	II	7681	. 6200 .	£\$.65	29.₽	II	9022.	9600	. 68. 29	64.8	II	183	11	£0.89	86	9.89	0080
1242	5500.	78.88	9 <b>5.</b> ₽	II	78E1.	9900	6 <b>þ</b> .83	₽0.3	II	5056	9900 .	06.62	80.7	II	E782.	7800	51.69	80.7	11	182	13	20.88	66	€.89	S\$10
1132	€200.	88.43	81.1	11	6921	₱900	28.62	29.₽	II	1892	3500 .	86.63	64.8	II	2206	9800	68.29	6Þ.8	II	87.I	11	60.89	86	9.89	0820
1248	2300.	69.65	95.4	II	9681.	9900.	19.93	₽0.8	II	9902	9500 .	10.09	80.7	II	₽8£2 <u>.</u>	7500	£2. £8	80.7	II	183	75	21.89	66	₽.89	9170
1422	7200.	£7.83	28.3	11	2291.	8300.	82.73	88.3	II	0882	8200 .	29.09	92.8	11	£072.	8600.	84.69	92.8	11	182	ÞΙ	28.78	66	1.89	0040
181.	3300.	17.88	\$6°\$	II	1791.	7 <b>2</b> 00.	09.95	97.3	11	2712	7800 .	28.62	79.7	II	£6∳2∵	7800.	88.29	79.7	II	₱8T	13	22.79	66	8.78	9790
1111	£300.	84.48	81.1	II	71242	2 <b>200</b> .	<b>6₽.6</b> 6	29.₽	II	1981	2 <b>2</b> 00 .	70.62	6₽.8	11	2712.	9£00.	₽9°29	6≱.8	II	183	π	28.79	66	1.89	0630
JOE RATE IH/HI	COND RATE IN/HR	SOFI TEMP 90	KNTS VEL LOCAL	моірзи	ICE RATE IN/HR	COND RATE IN/HR	SOFI TEMP To	KNTS VEL LOCAL	NOIDZY	301 3TAR RH\NI	COND AATE IN/HR		KNT\$	RECION	ICE RH/NI	COND RATE IN/HR	SOFI TEMP oF	KNIS VEL LOCAL	BECION	MIND DEG DEG	KN18 AEF MIND	DEW oF	HUM. K	TEMP.	LOCAL
		K STA 13					ELL ATZ					T OSE ATE					OLE ATE		)1			SNOITIGN	00		
6		7	$\bigcirc$		5326 5326	LL TIME:	FAST FII	7	E: 5303 NE: 5525	DOWN TIM	200א כאורר רא <sup>3</sup>		S :3MIT 1 TIME: 0				LLDOWN		Ą	<b>∀</b> 4	3	B1032	845	35	201 -VO
N.		Ď		0	6/8/T::	IMIT 0-T		06/8/	I				**************************************	70.044	e and the second second	qnuo	her So		- אורפ			00S		31	S15 - 32R

FIGURE 5. Ice/Frost Computer Predictions

AT 10:11 Icicles GMT at GMT 10:00. By G end of the duct. 10 minutes. reforming after Team at the on Ice again removed by the nad formed aga: with one 12:33 had cwo icicles
fell at were

venting area some interface and ed an ice/frost formation strut to LH2 tank inter condition was acceptable per NSTS-08303 documented thrust 002 **+**X Anomaly

ET/ORB formations readiness acceptable per NSTStheflightaround These test and 003. and were the purge vents observed on previous tanking on Anomaly cryoloadings were documented o formations and launch umbilicals have been Ice/frost firings,

This 102 occurred on previous launches and was acceptable the stations. i. accumulations a11 a t support brackets 004 recorded ice/frost bellows and support brac per NSTS-08303. has condition feedline Anomaly

of vapors from the GOX vent occurred has event This Anomaly 005 documented unequal flow item. information-only launches. an 88 previous ducts

point acceptable hard aft the was of It corner 006. +Y/aft c Anomaly the q recorded at formation was NSTS-08303. closeout frost

the was no evidence in the there οĘ missing paint. paint addition, located outside of missing the Ice/Debris Team. footprint topcoat. The areas were located it seal in the seated position and there fing to the seal or the TPS surface. In id to be no depth to the areas of missi areas small condition was acceptable to 007 recorded three chafing vent appeared Anomaly -Y GOX f GOX

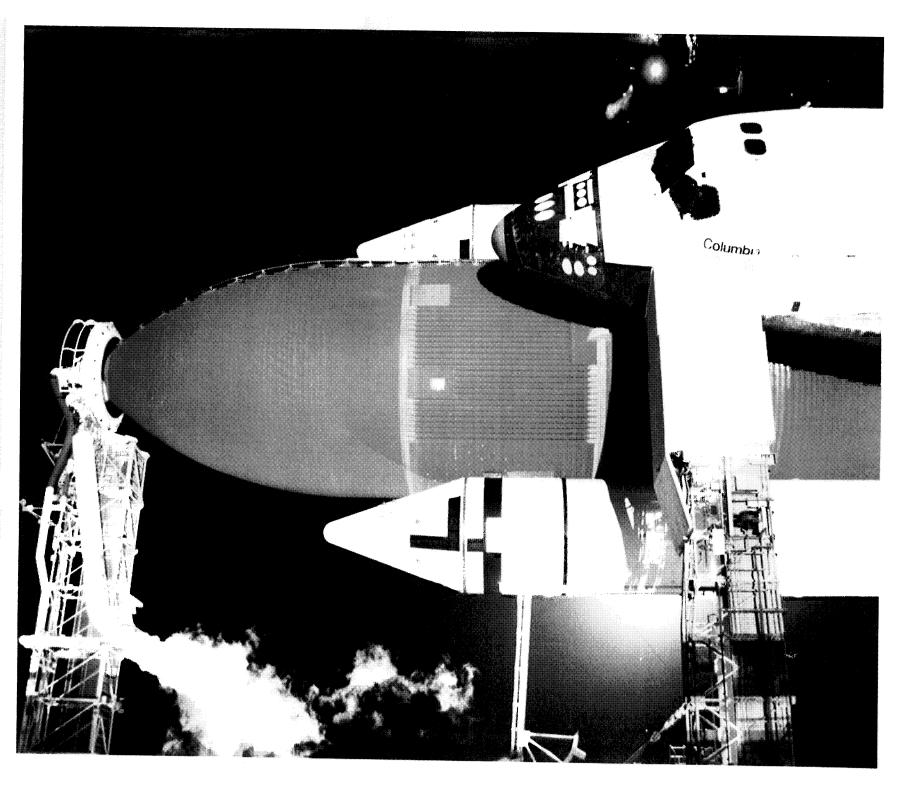
ly 008 documented an orange GSE tile shim protruding from lack tiles up to 1 inch over a 4 inch span on the lower RH approximately 4 rows inboard/aft of RCC panel 14. This ly was documented on PR RWNG-2-09-3199 and was accepted flight by MRB. the black Anomaly anomaly wing

## 4.5 FACILITY OBSERVATIONS

ETg resolved observations Was theprevented and no new items were noted during re observed on either the LO2 or LH2 expected, formed. at There debris concerns previously identified had been or and infrared ice had apparent leakage anywhere on the GH2 vent line interface. The modification to the GH2 vent line amounts of ice had to TSM umbilical. Was Visual and from forming but some ice/frost, waccumulated on the GUCP legs. Visual of the GOX seals confirmed no leakage. umbilicals, though small amounts lensate dripped from the LO2 TSM ice/frost, leaks were cryoloading N<sub>o</sub> condensate walkdown. t 0 T-0 A11

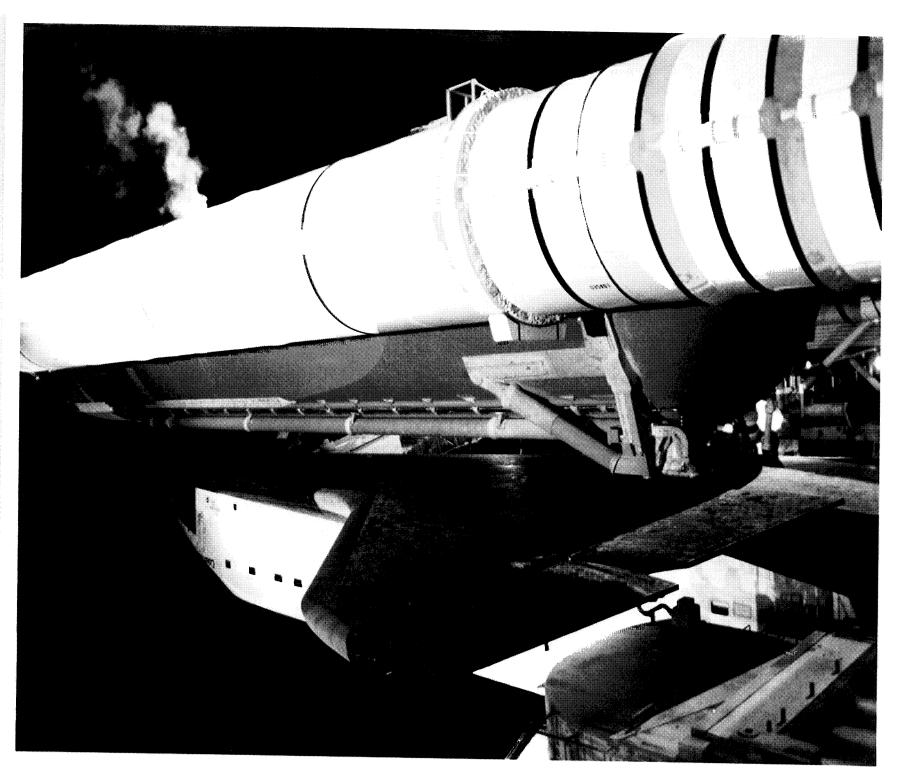
Icicles had begun to form on the ends of the GOX vent ducts during the ice/frost inspection. The icicles formed because the water diverters had not been installed on the vent pipes during the pad modification period. Four icicles, the largest measuring 8 inches long by 1 inch in diameter, were removed by the Ice Team using the specially designed retrieval net. A PR was initiated to install the water diverters prior to the next launch attempt.

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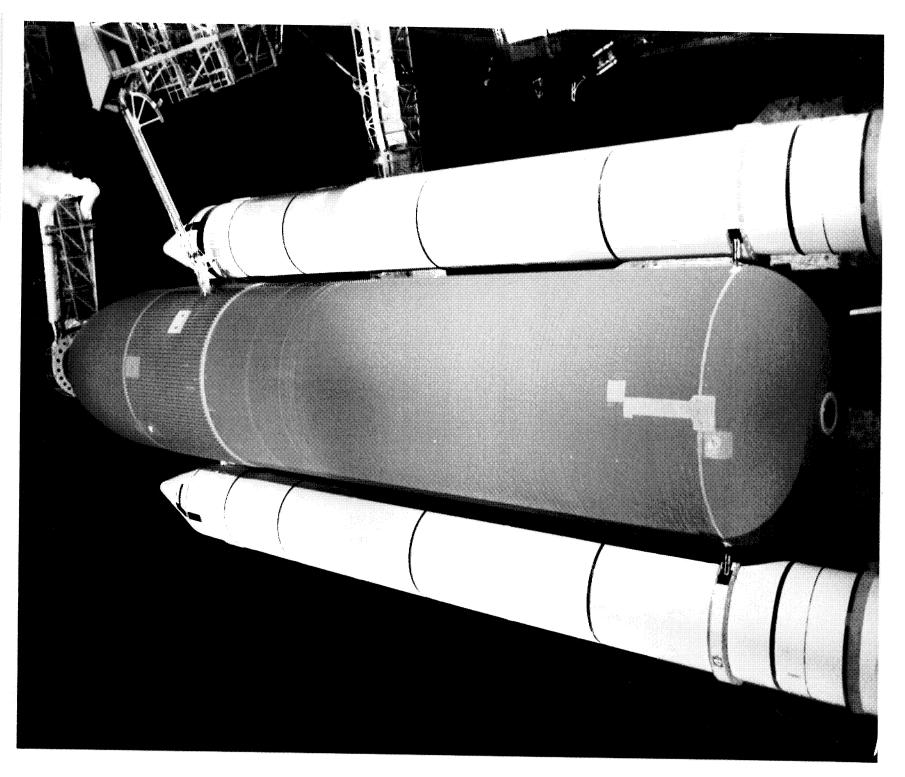
on the External Tank acreage areas. from the vehicle by southerly winds. No TPS anomalies occurred GOX vapors were blown away

ĝ .		Sp.		



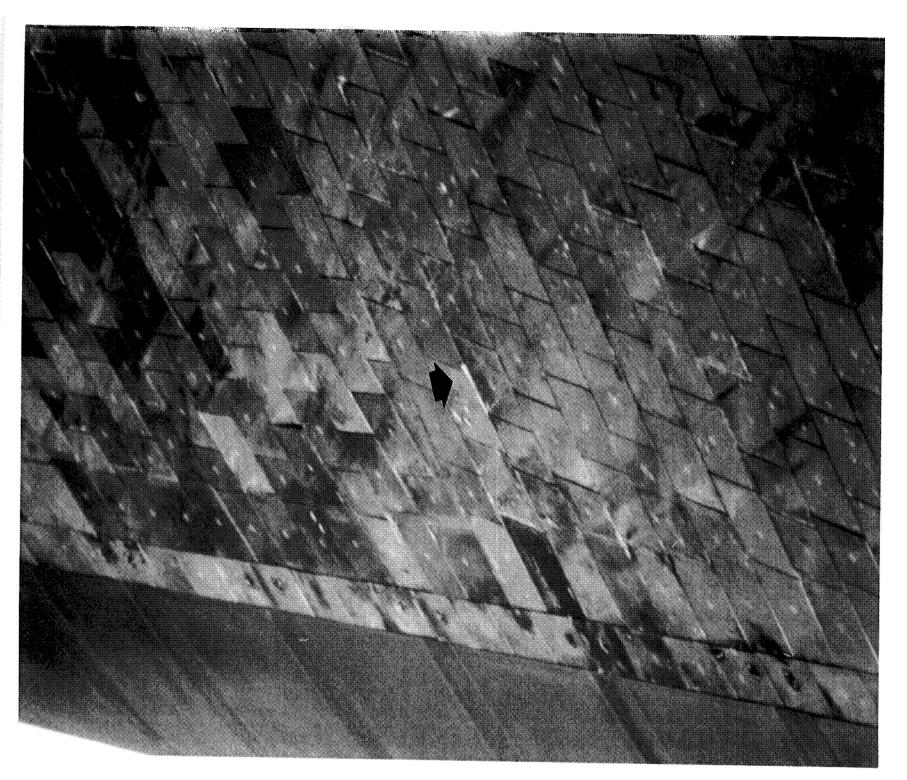
Overall view of the LHZ tank +Y+Z quadrant. Minimal ice/frost had formed on the ET/OPB LOZ umbilical.

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sides and SRB BI035 (LWT 25) 31 view of ET-32 Overall

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	4	1	9		
*					



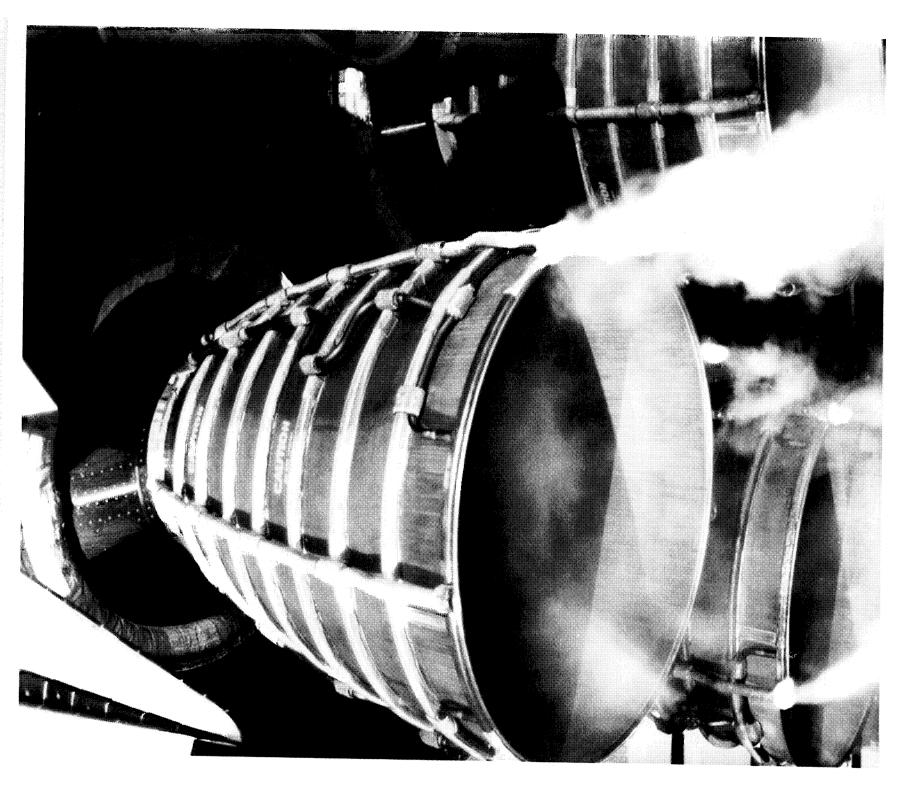
of black GSE tile shim protrudes from the 4th row aft of the RH leading edge RCC panel #14. orange 4-inch

€ 2°	A. A.		
		*	



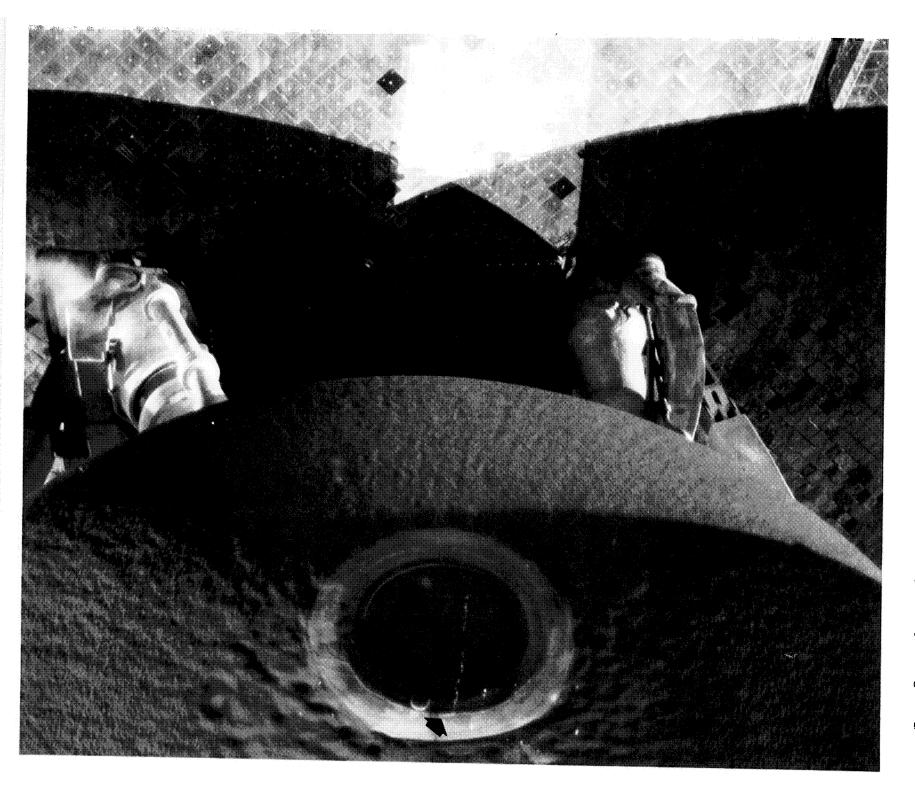
COLOR PHOTOGRAPH engine mounted Overall view of SSME's. Note frost line on the heat shield interface of SSME #2. 33

	\$ ş <sup>n</sup> .		4.	*		
			*			



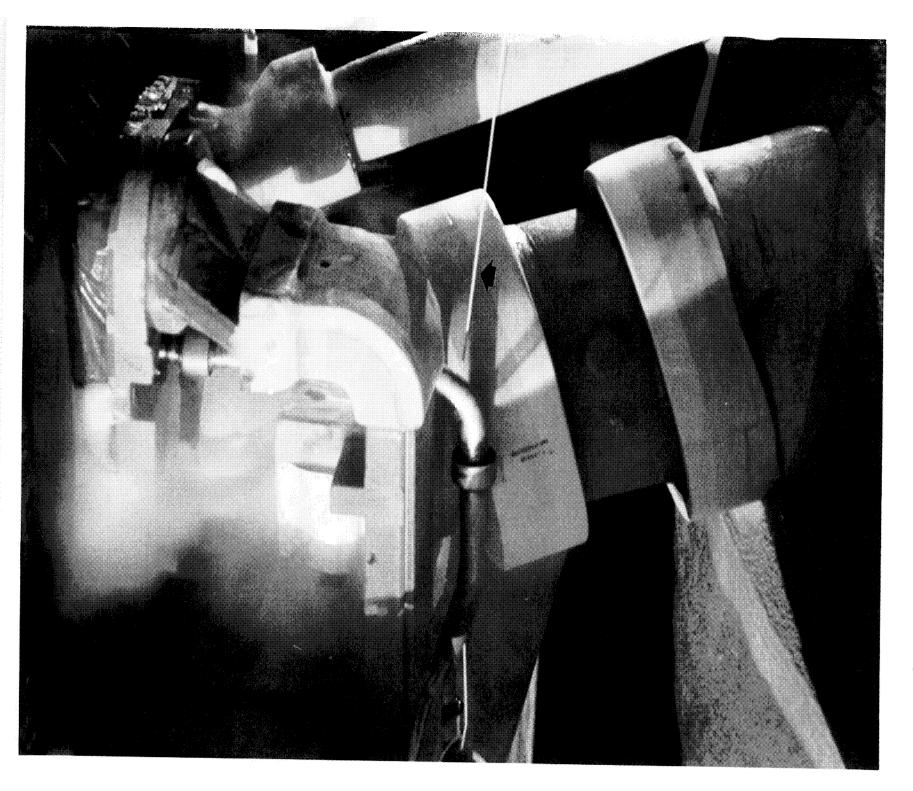
ORIGINAL PAGE COLOR PHOTOGRAPH GOX vapors from the drain line are blown into the SSME nozzle by wind and may be misconstrued as a leaking SSME LO2 valve.

Ş		<del>Ч</del>		



COLOR PHOTOGRAPH Ice formed on the aft side of the LO2 umbilical. Ice is present in the LH2 recirc line bellows, but not in the feedline bellows Note stream of condensate falling from the manhole cover (arrow).

S. Y



Ice formation on the LH2 umbilical and purge vent vapors are normal. Note retract lanyard for GH2 detection system (arrow).

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COLOR PHOTOGRAPH Hard ice has formed in the LO2 feedline lower bellows

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*	•	7	*		



crack caused a frost spot to form in the thrust
strut-to-longeron interface
38 small TPS

COLOR PHOTOGRAPH

φ <b>*</b>				
		*		
	*			



caused Omitting the hydro diverter on the north GOX vent duct dripping water/condensate to form 8-inch icicles

Å. Å		**************************************	· · · · · · · · · · · · · · · · · · ·		



Successful removal of the icicles by the Ice Team prevented TPS damage on the vehicle from falling icicles.

COLOR PHOTOGRAPH

ę v		
	¥ 6	
	S.	



of 30 pounds per cubic foot, vent duct by the Ice Team Icicles, with an estimated density were removed from the north GOX

	4			
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// 				

## 4.6 POST DRAIN INSPECTION

and tanks had been filled was performed at Pad 24-hour constraints inspection was performed 1990. Since drain jr combined. weather STS-32R launch was scrubbed due to warts abort site. Both the LH2 and LO2 post ercent. A post-drain inspection 1345 to 1515 hours on 8 January January inspection were 8 c the initiated, preflight pad debris Was Scrub Turnaround 100 percent. from 39A thet t

cover exhibited no anomalies. tumble valve The

acreage, formation siphon closeout dome tank as divots or cracks on the tank for a small amount of ice/frost bort closeout on the ET aft don also emanated from the port close port such vapors except check damage, manhole. Some visible the leak TPS Were

upper t t traycable SRB and RH both LH fairing interfaces. at accumulated had strut Ice

LH2 other **⊁**+ detanking the in after visible NSTS-08303 occurred was length, This has typically acceptable per in inches and was TPS. 12 crack, longeron vehicles

feedline Solid the LH2 umbilical and EB-8 LH2 recirculation line lower bellows. () was attached to five of the LH2 umb LH2 the covered EB-7 remained in thick still stillice and LH2 re long) was solid Ice 1 inch οĘ amount inches bellows purge vents. small 9 lower

Was θĘ solid support support brackets with heavy amounts brackets. The LO2 feedline suppo HCE Ą the No ice/frost was visible on the LO2 ET/ORB umbilical. ring of ice filled the LO2 feedline lower bellows. present in all feedline support brackets with heavy amcice in the lower two brackets. The LO2 feedline t 0 due inspected in detail þe not ice. could ion of accumulation brackets

other vehicles o previously occurred acceptable per NSTS-08303 of this ice/frost has Was and

SRB TPS or Orbiter thetο damage was no

had surface Ice Team inspection lower RH wing thetheSSE tile shim gage on since reported during GSE changed orange not

SRB sound suppression water troughs were full The

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## **And Photographic Analysis For** Debris/Ice/TPS Assessment Shuttle Mission STS-32R

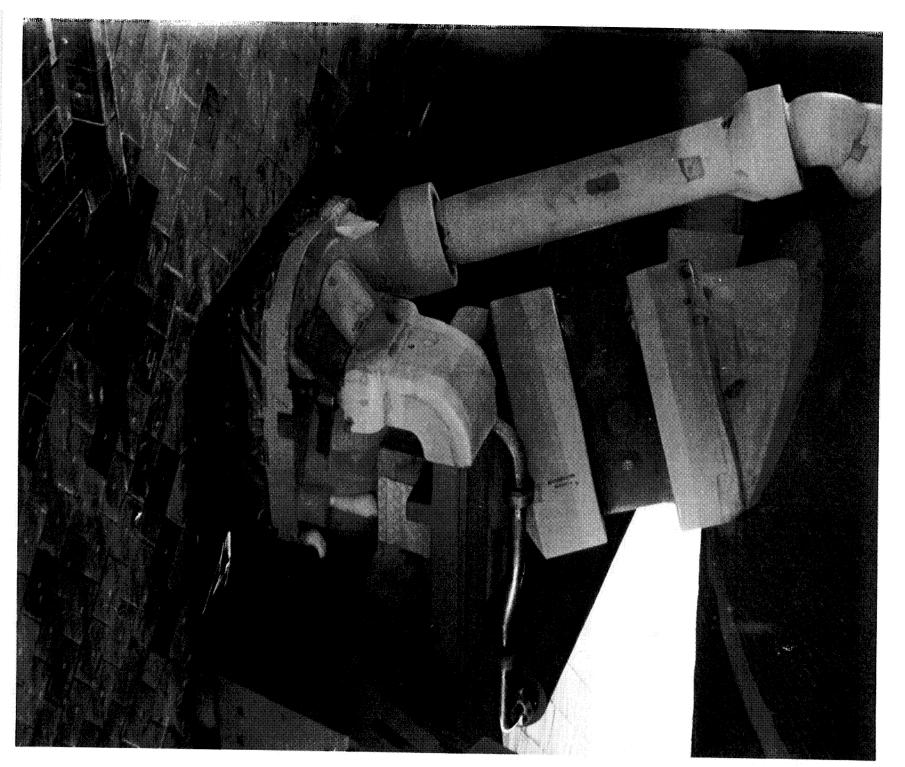
March 1990

63/16 UEBRIX/ICE/TPS ASSESSMENT ANALYSIS OF SHUTTLE MISSION 233 P (NASA-TM-102787) AND PHOTOGRAPHIC STS-32R (NASA)

N90-27733

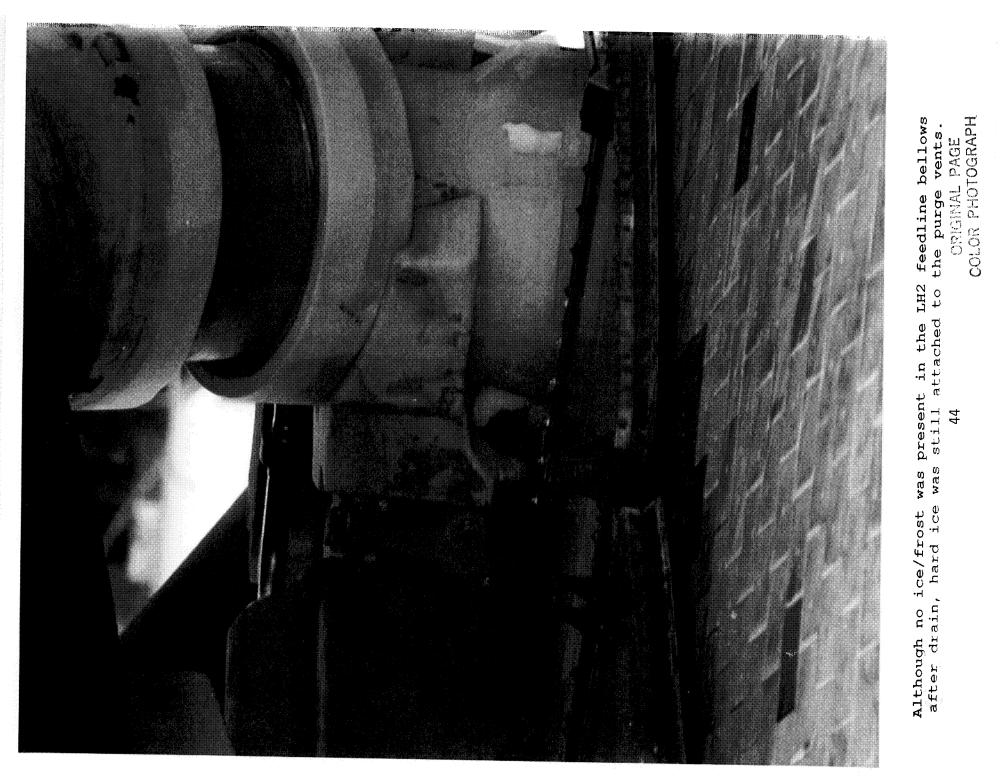
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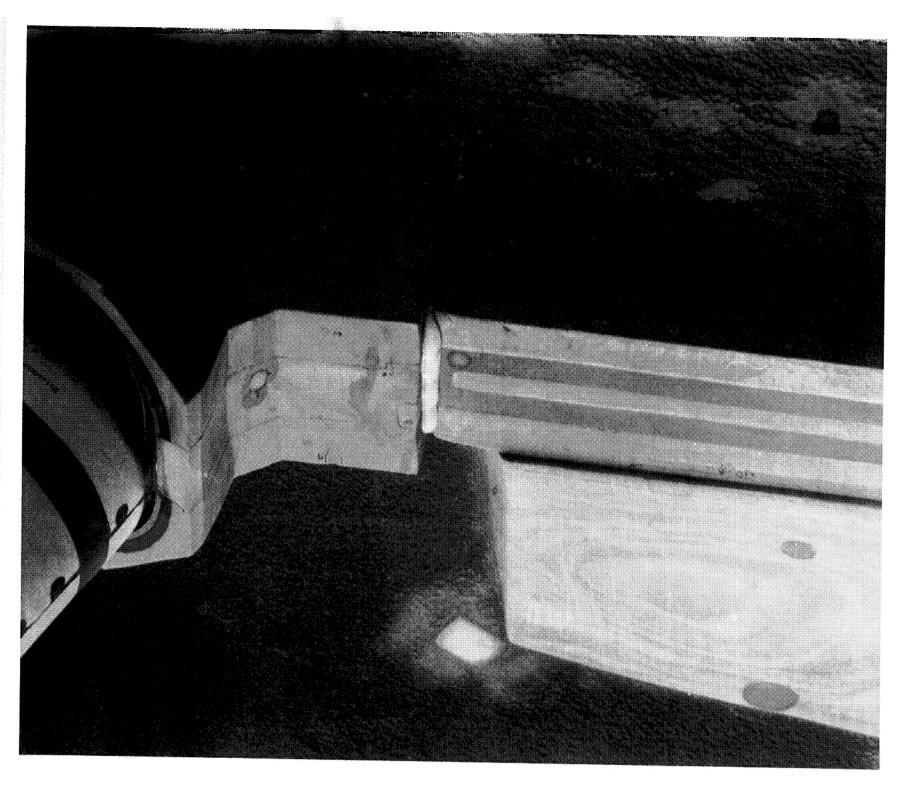


remained on the LH2 ET/ORB umbilical purge vents after the tank had been drained 43 Hard ice

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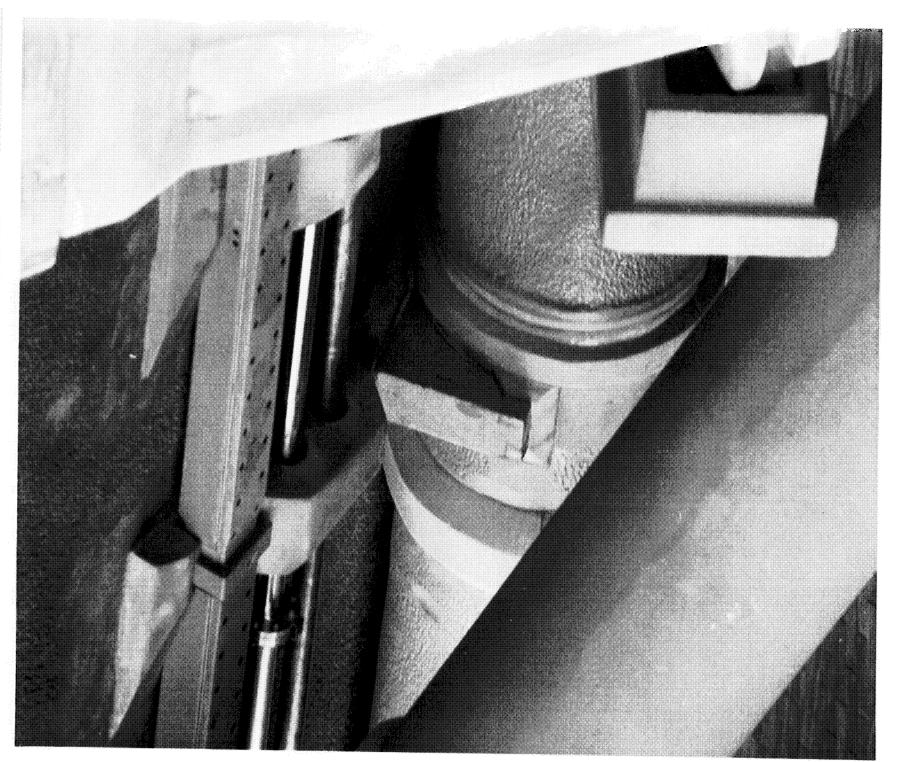
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ET/SRB cable tray and -Y Hard ice had extruded from both +Y splices 45

ORIGINAL PAGE COLOR PHOTOGRAPH

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OWENIAL PAGE COLOR PHOTOGRAPH support bracket and Hard ice was visible in the LO2 feedline lower bellows

	*					
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#### 5.0 LAUNCH

066 January 0 o 0735 EST at launched was STS-32R

### 5.1 ICE/FROST INSPECTION

There Criteria. the inspection were: during vehicle countdown. Commit loaded vel 0520 hours of the countdo Launch 0 from 0400 to CT-3 hours in t ψO  $\mathsf{the}$ time or  $\mathsf{the}$ Ice/Frost Inspection from formed on 9 January 1990 from hour built-in-hold at T-3 hour built-in-hold at T-3 hour holds of NSTS-08303 were no violations Ambient weather cor performed two

Temperature: 51.8 F
Relative Humidity: 100 %
Wind Speed: 5.5 Knots
Wind Direction: 276 Degrees

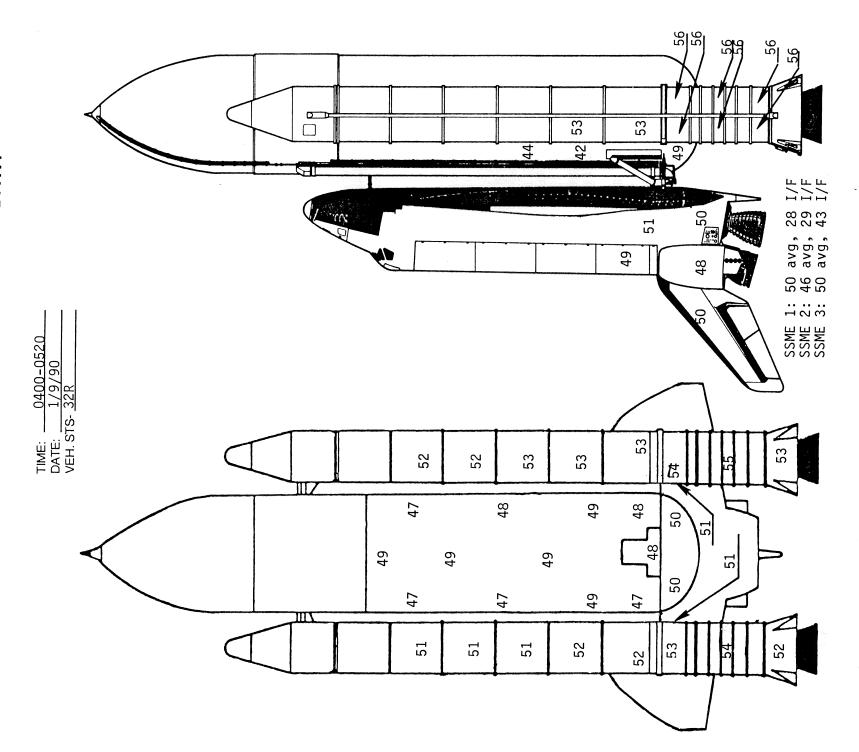
obtain assess nner was utilized to for an overall thermal was utilized 6 and as shown in Figure scanner temperature measurements infrared The portable STI is surface temperature ment of the vehicle,

### 5.2 ORBITER OBSERVATIONS

as 55 degrees F. The average engine mounted heat shields r SSME #1, 46 degrees F for #3. Frost lines were present Orbiter #1; the entire
: #2. There was entire documented the observed. The average interface: SSME on SSME than those d 0 #3 heatshield. other anomalies, Orbiter tile ON

### 5.3 SRB OBSERVATIONS

surface Temperature in u The ranged from 73 Mean Bulk Temper anner recorded RH and LH SRB case 52 to 57 degrees F. Temperatures 1d joint heaters ranged from 73 observed. Were ablator/cork The predicted Propellant degrees F 65 loose scanner (PMBT) supplied by MTI was SRB field temperatures between 01 infrared anomalies area of the degrees F. portable SRB ON



# 5.4 EXTERNAL TANK OBSERVATIONS

The a11 2253 accumulation on 8-11. from Figures was in ice program tabulated with no computer e results condensate t prediction and the resu acreage surfaces. program predicted ice/frost hours 0735

average surface 53 degrees F on Intertank erature of 49 degrees F on the LO2 tank, 53 deg Intertank, and 47 degrees F on the upper and condensate was present on the LO2 tank, The IR scanner measured an and LH2 tank. temperature of Acreage

SLA ve inch. approval 3/8 apex. dispositioned with MRB was protruding occurred on the aft dome diameter and in taken 2 inches anomaly Was closeout TS-0063

repair and 1 and , defects, aft corner tank longeron . A 1-inch diameter TPS forward of the longeron LH2 was covered by frost. acreage ice/frost, appeared on the theof condensate trickled down spot TPS anomalies. A small frost sprine third hardpoint closeout. foot outboard of the cable tray, 4 feet side, dome. anomalies. A acreage +Y amount aft theaverage off TPS a on the ran Ā σŧ

The struts strut thefittings outboard to rest of the fitting. dry and were not covered by ice. Ice/Frost covered the lower EB
pin hole with condensate on the

on t the area was cracked, but which occurred in the ith frost. Ice filled J O (iceball) in side TPS frost. Ico section 2 feet below the attach point. strut to LH2 tank interface area was crwith ice/frost. Small cracks, which occur 2 inch long line at with trays filled cable ๙ with ice/frost. Small a the +Y side, were i e +Y side, were of both ET/SRB exhibited fairings. longeron upper strut interface on filled sanded thrust The

ο£ normal exhibited normal accumulations fingers, nts and no vents Frost on the purge sides. frost on both the aft and inboard average in size, had formed on venting was occurring. LO2 ET/ORB umbilical

covered with ice and frost. Frost Ice/frost was average. evidence Ice/frost greater E the purge vent frost fingers was acceptable per NSTS-08303. There ation on the LH2 ET/ORB umbilical was gr coverage was acceptable per NSTS-08303. The al vapors emanating from the umbilicals or any feedline bellows were the aft inboard side in the LH2 recircul accumulation covered unusual The LH2 normal. formed

LO2 feedline filled with normal-tofeedline support brackets were filled the <del>.</del>ц vapors were present upper bellows were LO2 feedline A11 The ice and some lower bellows. heavy hard ice.

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### \$200 ONLY   \$2	, W	人	人	<u>(1)</u>	0	6/6/T;3 6:0132	TAO	<del></del>	06/8/	17		-41				<del></del>			<sup>2</sup> 01	Q.A	<del>~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~~</del>	ุศ โลนก	4000S	882	1	STS - 32R
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7777 2800. 88.8 18.8 11 8700 8000, 6200, 6	160.550	00.	62°SÞ	92.7	ΙΊ	2600.	8200.	17.48	83.2	II	.0318	8200.	18.68	₽9.6	II	6830.	4100	70.8±	₽ <b>9</b> .6	II	273	9	12.83	64	7.62	2300
FYFY (2500) 8C.84   F.E. II   3700   6200, 60.4c   0.c.   II   c100   c200   c0.4c   c1.4c   II   c200   c200   c200   c2.4c   c200   c200   c200   c2.4c   c2.	32 1534	:00.	08.94	89.6	II	_020 <u>-</u>	1600.	31.78	3.44	II	-020 <del>-</del>	1600.	37.15	P. E	II	6 <u></u> 470 <u>-</u>	6100	78.8£	4.72	II	182	8	52:84	28	8.83	\$312
8800   7800   90. ph   79. 8   11   8000   90.00   12. 85   10. 8   11   8200   12.00   10. 8   11   8200   12.00   10. 8   11   8200   12. 90. 90. 12. 8   11   8200   12. 90. 90. 12. 8   11   8200   12. 90. 90. 12. 8   11   8200   12. 90. 90. 12. 8   11   12. 9800   12. 980	1771 35	:00.	8£.8¥	18.81	II	20 <u>40</u> .	₽£00°	\$2.0\$	£7.4	II	₽₽40 <u>.</u>	££00.	11.44	6 <b>}</b> .8	II	1023	0020	6I.8Þ	6 <b>p</b> .9	II	197	II	18.23	<b>7</b> 8	9.78	2330
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2750. 8500. 26.24 82.7 II 000. 87.64 82.8 II 000. 2500. 00.26 82.8 II 0710. 0500. 12.36 \$2.6 II 88.0. 0500. 83.24 \$2.6 II 082 80.0 87.64 83.6 II 000. 87.64 83.6 II 0	34 089	:00	60.pp	7≱.8	II	9900.	0600.	13.68	3.01	II	7820.	1800.	34.88	£1.13	11	8230.	0200	44.25	£1.1	II	263	L	78.13	98	0.93	0000
100   100	38 0 86	300.	Z9.£₽	7₽.8	II	a 500.	0500.	66.SE	10.8	П	<u>-</u> 0264	1800.	<b>₽6.7</b> £	£1.13	111	-0534	0020	97.£≱	£1.1	II	273	2	65.13	48	<b>≱.</b> 66	9100
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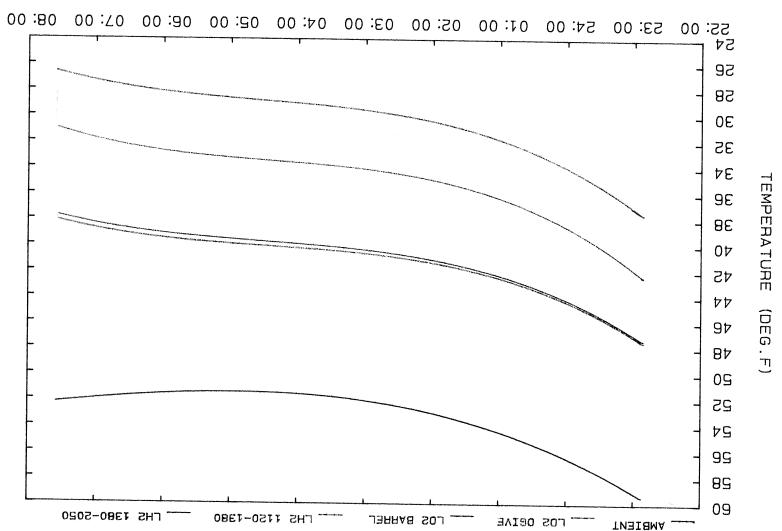
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16†0. -	6400	133.68	92,7	11	0030.	0800	38.85	85.5	III	6₹00. -	8600	81.88	3.54	II	9120.	0023	. TT. EE	3.54	11	284	9	£8.02	66	1.13	0090

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PAL outlined greater  $\operatorname{The}$ than repair between station XT-1282 striction line ice/frost ramps were outlear the pressure. ice was ounts near the pressurization line at with frost. theοĘ and thickness from the previous day's pressurization the acreage in amount ice. .... aft locations. barrymounts and aft ringed amount frost with

on the interas present on the inte e GUCP, but there was in the -Y-Z stringers flange. A frost spot 1.5 inches tank-to-intertank flange between frost Was the Minor frost had formed arcumor of leakage. Ice/frost accumulated tank 102 thethe LO2 tank-to-intertank diameter formed on the LH2 from condensate bipods. tank. sign

the ogive. The prevailing wind was out of causing the GOX vent vapors to pass within but no ice formed in the ice-free ronner o N during tact with no sign of degradation. were visible on the LO2 tank. No replaced cover, which was not intact with no sign of the north-northwest causing 4 feet of the ogive, but no or anomalies present on The tumble valve remained Was recycle, defects sate the

not the t 0 Was tygon tubing wo to lack sensor due detection scrub the hydrogen after reinstalled The ET/ORB vehicle.

consists Ice/Frost Team observation anomalies OTV recorded items: summary of 12

LH2 mold inches from the taken approximately 2 inche inch beyond the outer Was am plug protruding 1 7 is approximately 3/8 inch hom PR ET-32-TS-0063 use-as-is. t t foam Anomaly 009 recorded a PDL foam tank aft dome apex. The plug diameter and protrudes 1/4 to 3 line and is surrounded by ice. dispositioned with MRB approval

condition was acceptable per NSTS-08303. Anomaly 010 documented an ice/frost formation on the This clip closeout.

Some venting and ice/frost formation in the TPS crack at the +Y thrust strut to LH2 tank interface was documented on Anomaly 011. This condition was acceptable per NSTS-08303.

more than usually s acceptable per Anomaly 012 reported the accumulation of ice at the ET/ORB umbilical interface. The ice accumulation was more than usua cryoloads, but was acceptable during previous NSTS-08303. observed

previous documented ice/frost fingers on both ET/ORB LH2 q occurred acceptable per NSTS-08303. has condition This vents. WAS and Anomaly 013 LO2 purge launches

uneven from documented flow The only, ducts. information vent GOX the for from greater. taken 014, take was north duct Anomaly venting

and sedline support brackets at all stations was documented ily 015. This condition has occurred on previous and was acceptable per NSTS-08303. bellows feedline LO2 theij ice/frost σĘ accumulation feedline Anomaly launches

on the intertank accept This condition was accumulations tanks. 016 recorded ice/frost LH2 and LO2 NSTS-08303. to both able per Anomaly flanges

rormation on the +Z surface acceptable per NSTS-08303. 017 documented an ice/frost formation on the +Z and was -Y longeron closeout Anomaly of the

station 018, formed at Anomaly tray diameter, cable on An in the documented inch οĘ side Н approximately to the +Y s foot to the +Y his condition, acceptable per NSTS-08303. This frost ball, location 1 XT-1780.

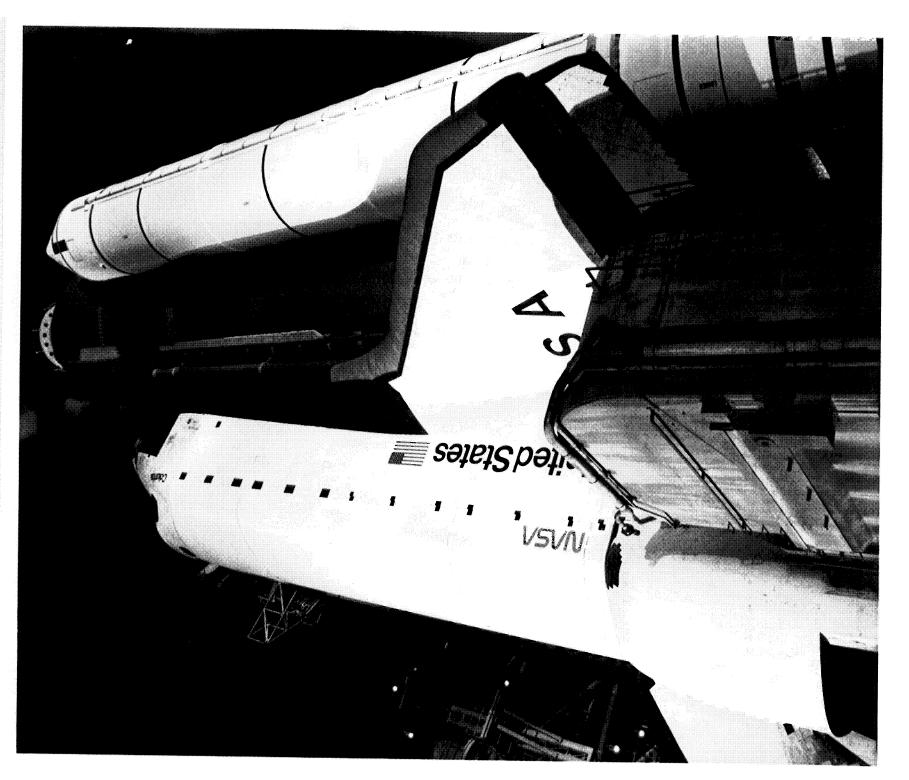
ice/frost formation along the Frost along these bondlines are acceptable per NSTS-08303. the formation of frost alc station XT-1270 to 1528. recorded the from bond line 019 Anomaly

in texture the north Ice/Debris Team. end of light i theto be 020 documented frost formations on GOX vent duct. These formation appeared and density, and were acceptable to the Anomaly

## 5.5 FACILITY OBSERVATIONS

launch removed from diverters minor ends đ occurred during the first ducts. inc the o accumulated on the duct exit plane. diverters were formation formed, vent icicles with icicle water Pad A nt ducts, which had previous day, the installed on the P properly and no problem eliminate the of frost vent the functioned and GO% attempt amount

leakage ice/frost Visual ice/frost, leakage. The sound suppression water troughs were full of waper design. There were no facility anomalies. GUCP. The modification GUCP legs. was no apparent debris concerns had been identified during the tion of the vehicle. There was no apparent e on the GHZ vent line or GUCP. The modificatint line prevented ice from forming but some i but some theice from forming accumulated on tons of the GOX expected, had which was expeand infrared inspection anywhere vent No new

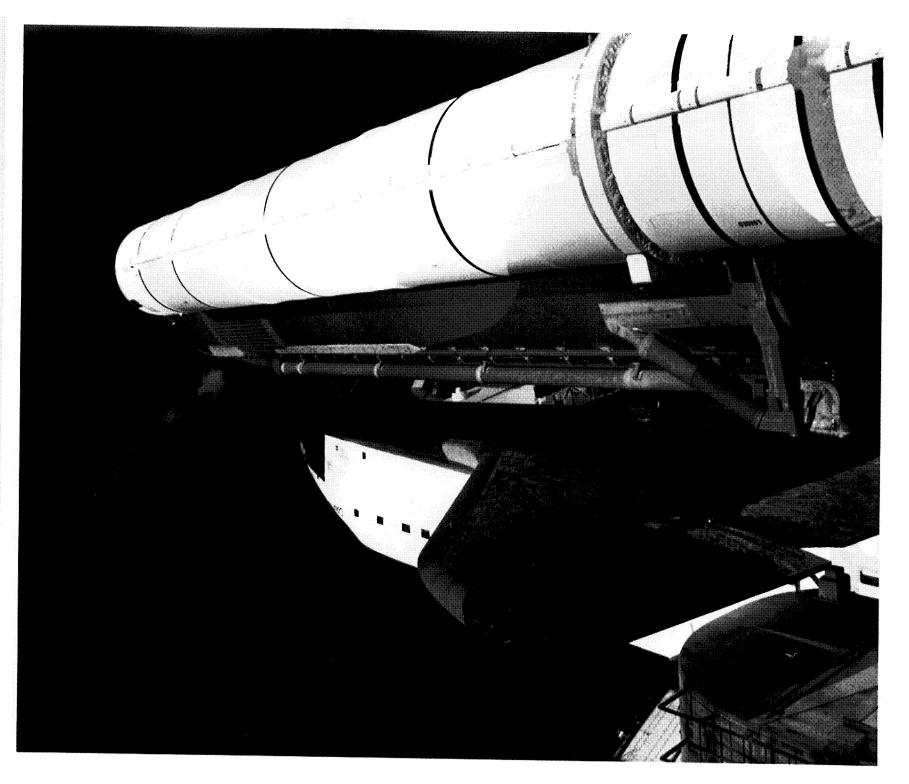


ORIGINAL PAGE COLOR PHOTOGRAPH and BI035 Overall view of OV-102 Columbia, ET-32 (LWT 25), after the second cryoload 57

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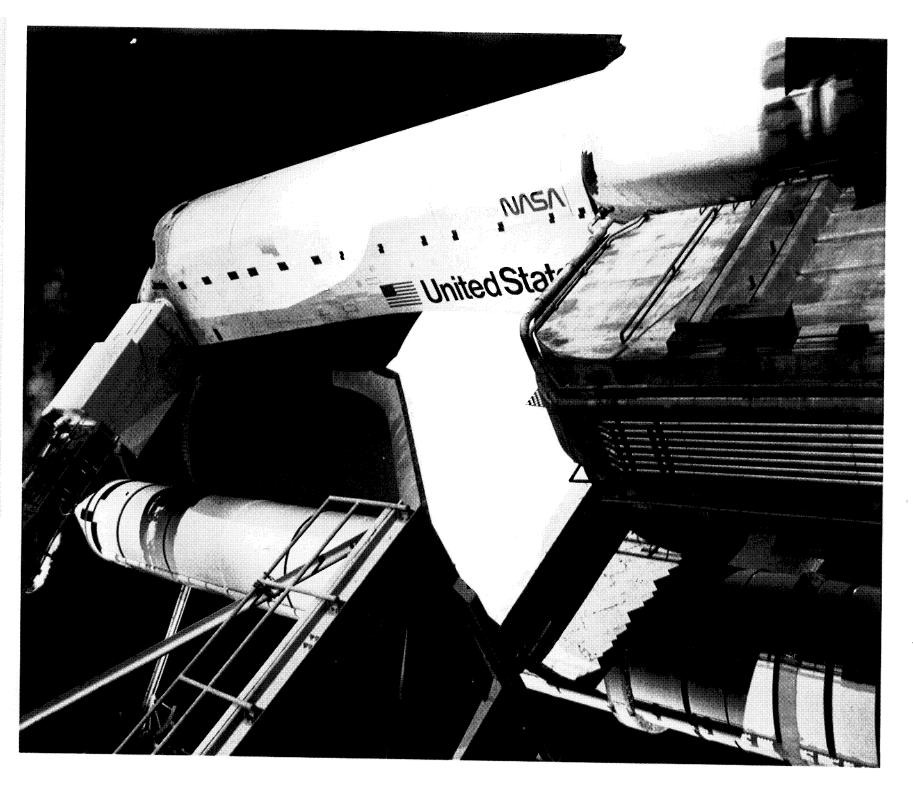
ORIGINAL PAGE COLOR PHOTOGRAPH

No ice/frost had formed on the acreage in the +Y+Z quadrant though a frost line formed along the PAL ramp



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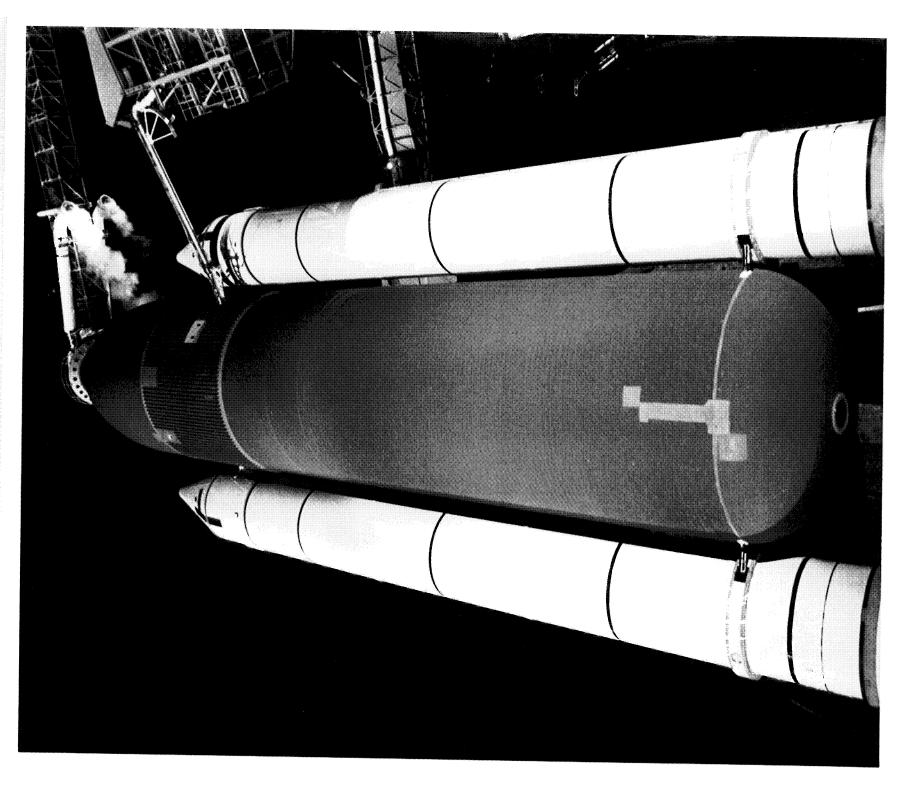
-Y+Z quadrant the No ice/frost had formed on the acreage

4	in the second se			
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Although westerly winds blew GOX vapors past the LO2 tank ogive, no ice/frost had accumulated in the no-ice region

ORIGINAL PAGE COLOR PHOTOGRAPH

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side TPS acreage 7 was present of the Only condensate

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view of the SSME's. Note ice/frost on the engine heat shield interfaces and SSME #2 LO2 drain line Overall view mounted heat

ORIGINAL PAGE COLOR PHOTOGRAPH

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ORIGINAL PAGE COLOR PHOTOGRAPH Ice/frost accumulated on the SSME #1 engine mounted heat shield-to-nozzle interface

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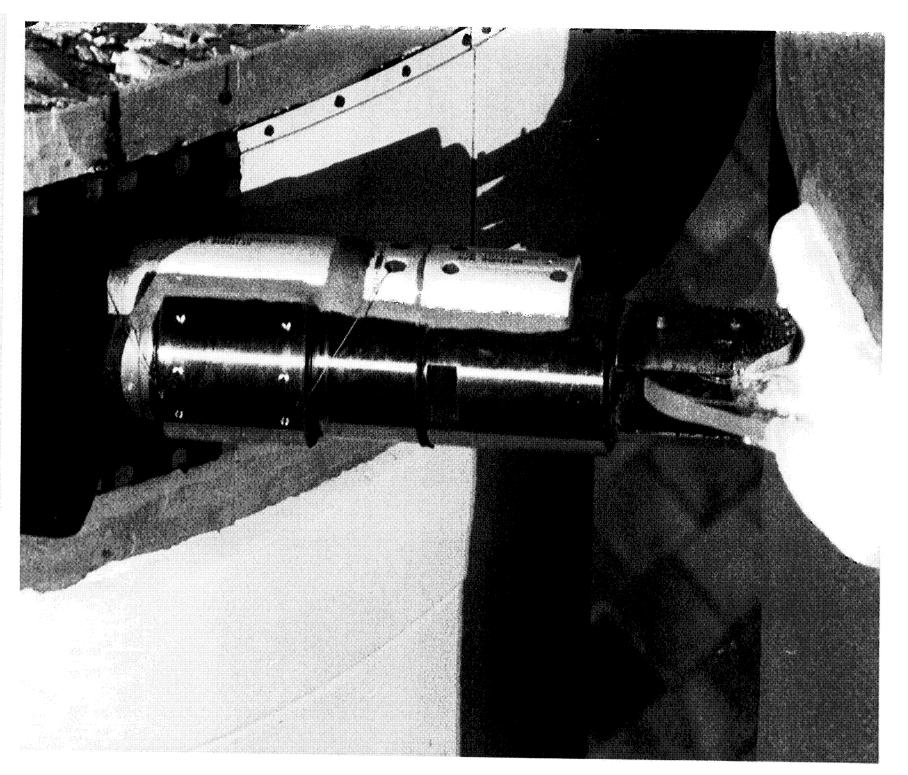
SSME #2 exhibits condensate on the engine heat shield and frost along the interface. Note frost spot on base heat shield vent.

64 OBYGINAL PAGE COLOR PHOTOGRAPH

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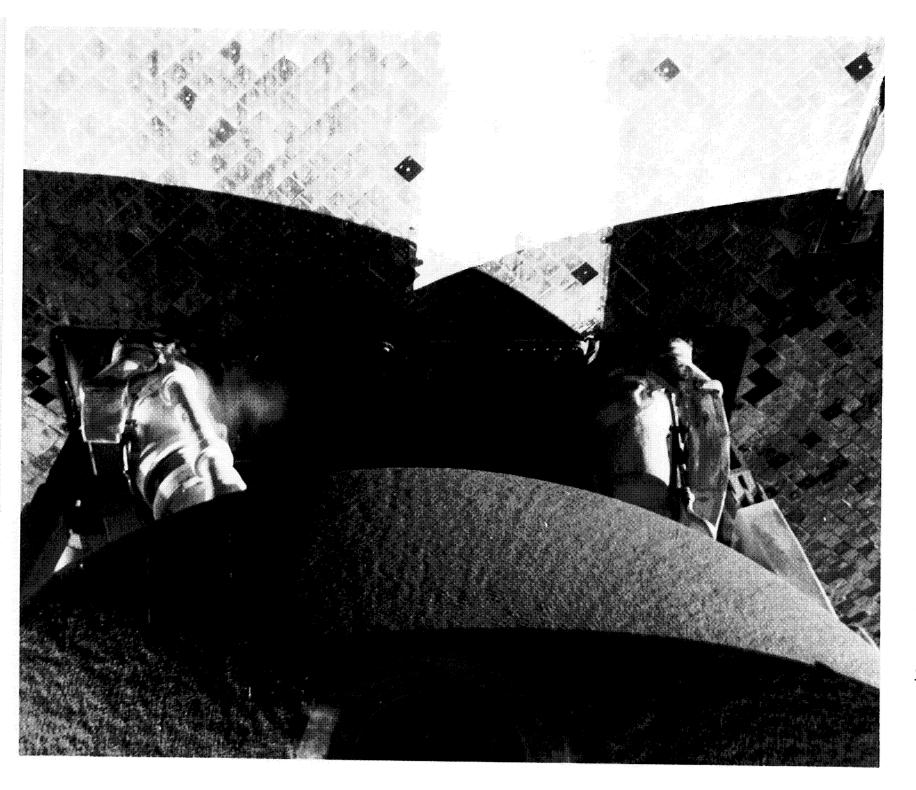
COLOR PHOTOGRAPH dome apex 3-inch diameter repair on LH2 tank aft begins to protrude due to cryopumping Previous

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Although ice/frost covers the EB-7 fitting, only condensate is present on the lower strut clevis

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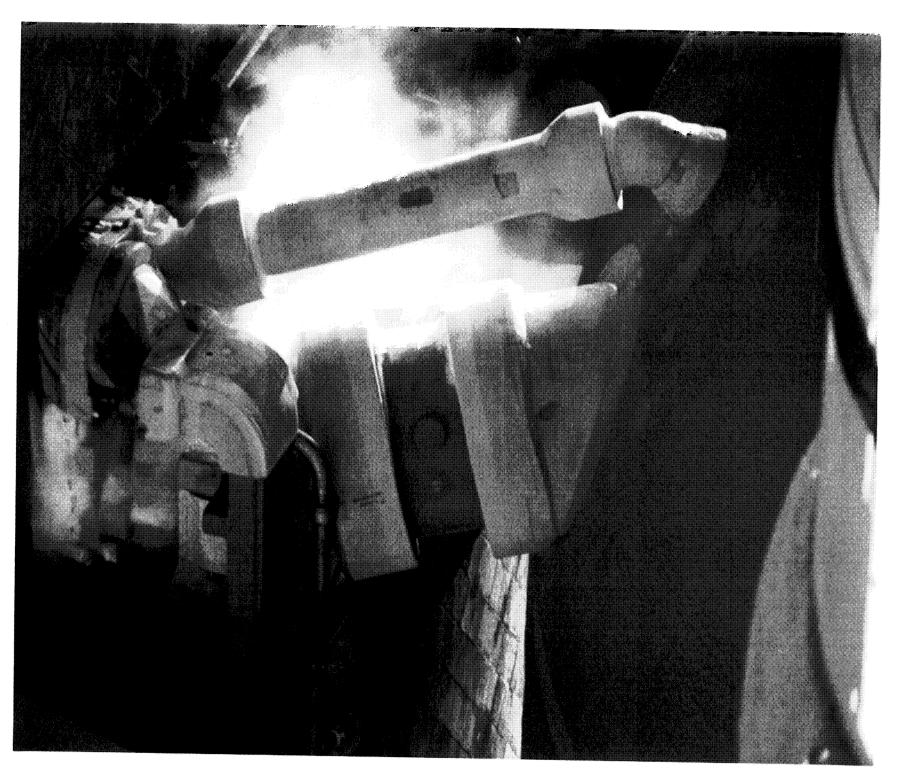
Ice/frost formed on the aft side of the LO2 umbilical, in a LH2 recirculation line bellows, and on all purge vents

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Minimal ice/frost has accumulated on the LO2 ET/ORB umbilical baggie and purge vents. Note condensate drops on the cable tray

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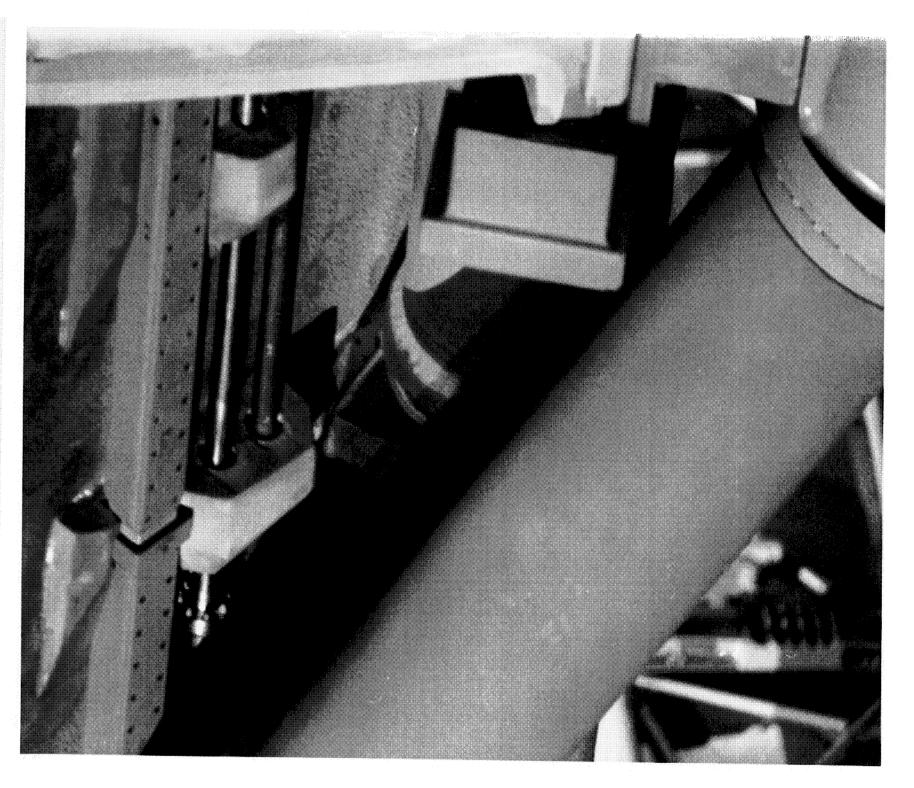
Ice/frost accumulation on the LH2 umbilical baggie, purge vents and in the feedline/recirc line bellows is heavier than average

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Frost has formed along the cable tray ramp aft side and in small TPS crack at the longeron-to-thrust strut interface

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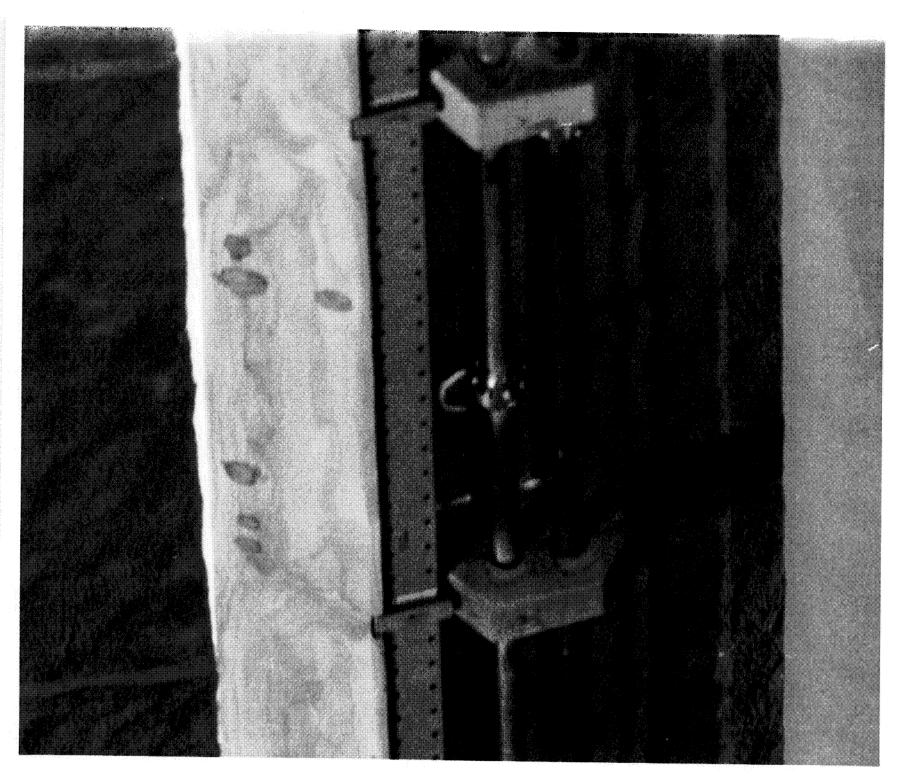
ORIGINAL PAGE COLOR PHOTOGRAPH A somewhat heavier-than-usual accumulation of hard ice is visible in the LO2 feedline support bracket and lower bellows

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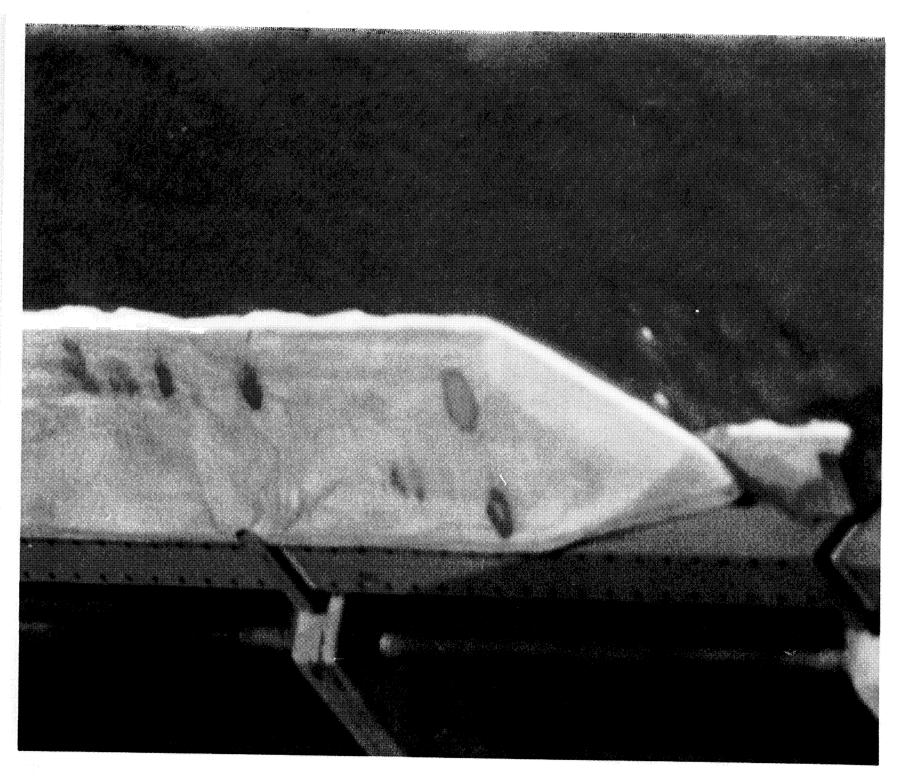
feedline support brackets were filled with a normal accumulation of ice/frost Upper LO2

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outlines the LH2 tank PAL ramp, pressurization line ramps, and a previous 3-inch diameter repair Frost

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and cable tray ramp, acreage repairs Frost outlines the LH2 tank PAL ramp, a c 74



Installation of hydro diverters on the GOX vent ducts after the

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## 6.0 POST LAUNCH PAD DEBRIS INSPECTION

tile screed was round. The screed was an turned in to Operations. The screed was an 364 repair on tile V070-197004-069, which was launch inspection of the pad and surrounding area 9 January 1990 from launch + 2.5 through 5 hours. The pad apron, and acreage areas were inspected. A large white tile screed was found west of the FSS in the box and turned in to Operations. The screed was an inches closeout plugs (foam and RTV) was found. Water trough material from exhaust holes was scattered from the pad apron to the throat screed measured the forward, outboard corner on the RH er surface. The piece of screed measus aximum thickness (the original tile is 1. other significant flight hardware or TPS SRB d with the exception of three Q-felt Orbiter base heat shield. The usual S elevon upper surface. The 5/8"x1/2" maximum thickness and RTV) was white tile son and turned thick). No other were found with tfrom the Orbiter the SRB exhaust perimeter fence. (foam unrestricted in area MLP, FSS, post of began on located material piece

rt purge lines joint hert #2 shoe of shim in debonded launch. the closed position, exhibited no apparent damage, and did n appear to be missing any parts. The SRB aft skirt purge lin were in place and slightly damaged. The SRB joint heat umbilicals showed minor damage after separation. visible. All SRB holddown post erosion was normal for this launch. holddown post shim material was intact, but had debc significantly from the shoe sidewall. The shim on HDP #2 was completely debonded and could be lifted. Two pieces of material were found. One appears to be from a previous land conditions indicative of stud hang-up were visible. Al f stud hang-up were visible. on the north holddown posts doghouse blast covers holddown post shi conditions

pad the Several pieces of facility debris were found on the perimeter. The number of facility items found was typical.

vice Masts (TSM) vent hood windows later fourth SRB found on the pad. The GH2 vent arm was latched on the fountooth of the latching mechanism and showed signs of typical splume heating. The static retract lanyard caused no damage the hood The Orbiter Access Arm (OAA) and Tail Service Masts showed signs of slight launch damage. The GOX vent hood wi were broken and the protective foam on top of the hood partially pulled back. Two pieces of the hood window were found on the pad. The GH2 vent arm was latched on the f GUCP

o secured All seven emergency egress slidewire baskets were sethe FSS 195 foot level and sustained no launch damage.

Overall, there was very little damage to the launch pad.

Patrick AFB and MILA radars had been configured again in a mode for increased sensitivity for the purpose of observing any debris falling from the vehicle during ascent. Although the signals were very weak, a total of 29 particles were imaged in the 138 to 320 second time frame. Most of the object are small, sections are objects with somewhat larger cross relatively, but

and from also seconds falling f are )5 seconds. Particles at 117.5 and 118.5 se 305 separation οŧ and correspond to pieces ume during tailoff. 169, 151, the plume during visible at 151 visible before would

The debris inspection continued on 10 January 1990 and was expanded to include areas outside the perimeter fence. Ground teams searched the beach, railroad tracks, and beach access road from the northern KSC boundary to the Titan complex. The NASA helicopter was utilized to cover the water areas around the pad, the beach from the Cape lighthouse to a point 10 miles north of the pad, and the ocean area under the flight path. No flight hardware was found.

holddown posts the sandboxes in the debris recovered:  $\mathsf{the}$ During MLP refurbishment, the were opened and the following

1/2" metal fragment, 1" long metal wire two francible nut webs	one NSI cartridge, 3/8" metal fragment, 2"x3/16" sliver of ribber	six small (less than 1/2") fragments, one is a piece of francible nut web	one frangible nut web	one piece of NSI cartridge with threads	1-1/2"x1"x1/2" nut fragment	1/4"x1/8" fragment	1/2"x1/2"x1/8" metal fragment	None	3/4"x1/2"x1/8" NSI cartridge fragment	with threads	1"x1/2"x1/16" cartridge fragment	4 very small fragments
##	:#=	#4	#2				#6	#7	#8			
HDP	HDP	HDP	HDP				HDP	HDP	HDP			

11.1 Section listed in are anomalies launch pad Post



ORIGINAL PAGE COLOR PHOTOGRAPH a south SRB holddown post. Note the holddown post shoe. launch condition of debonded shim on Post

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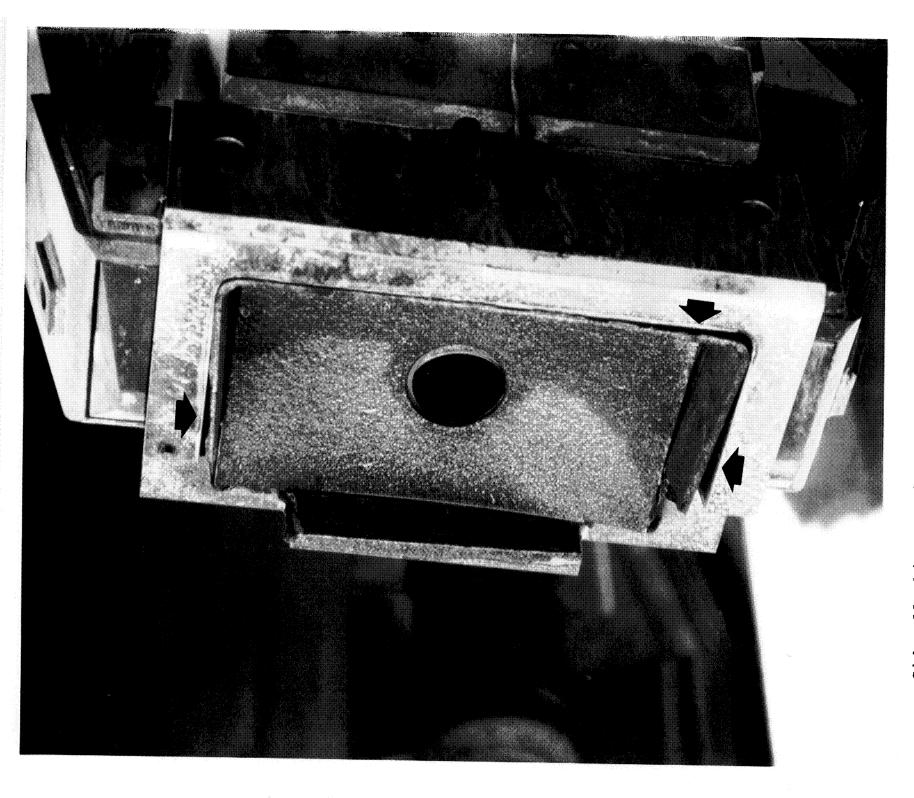
Post launch condition of a north SRB holddown post.

COLOR PHOTOGRAPH

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shoe #2 shim on holddown post Debonded Epon



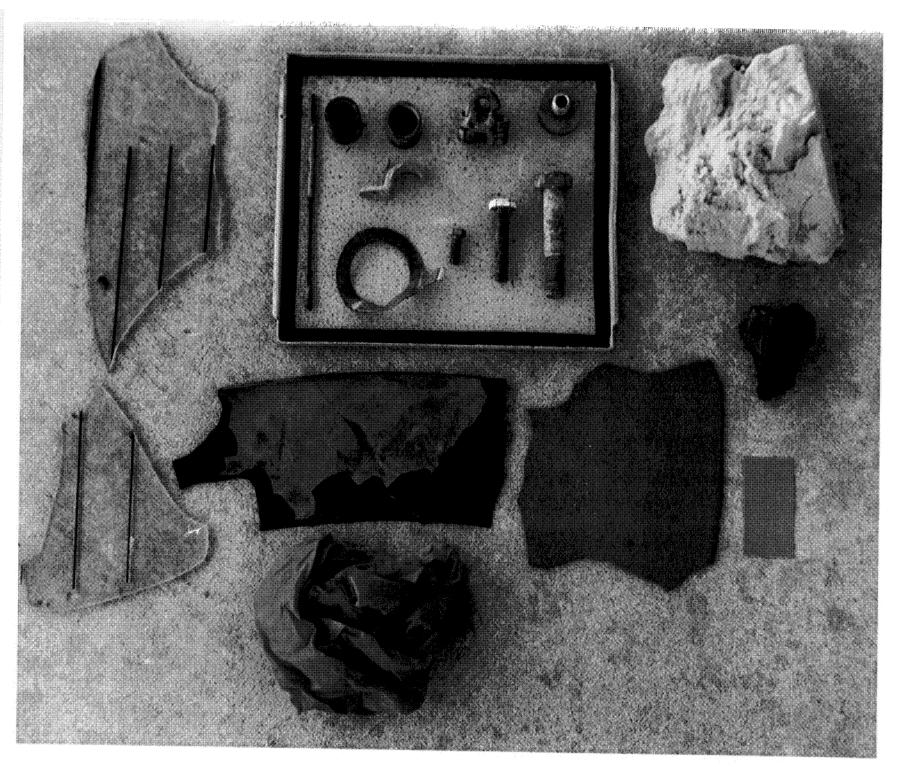


completely debonded was almost shim material Sidewall

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The GOX vent hood sustained launch damage in the form of broken window and torn insulation on the plenum chamber

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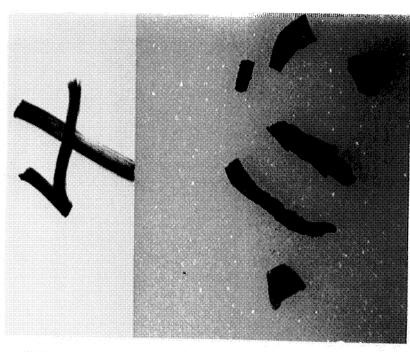


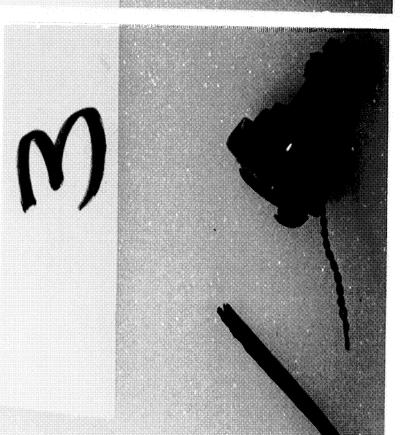
Typical debris recovered after launch. Note orange GSE shim and pieces of window from the GOX vent hood.

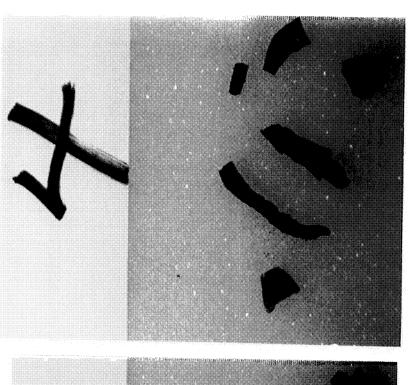
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elevon tile shim material outboard and HDP  $\mathbf{R}\mathbf{H}$ Q-felt plugs, includes debris shield launch post Other screed,

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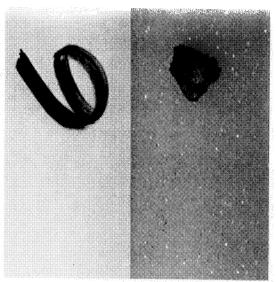


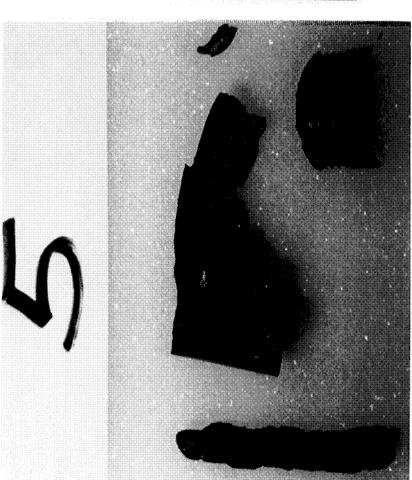


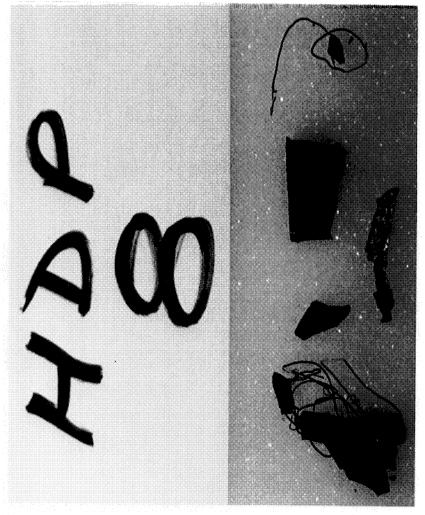


revealed nut sandboxes frangible of RH SRB holddown post cartridge and pieces of Examination an NSI

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post sandboxes revealed and frangible nuts of LH SRB holddown post from NSI cartridges and Examination pieces

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## 6.1 POST LAUNCH CREW COMMENTS ON DEBRIS

separation: From Commander Dan Brandenstein after SRB

on the ascent debris. Houston - Columbia, ia - Houston. We didn't see anything unusual. A couple of kind of whitish, looking things going by the side. Also, rward windscreens received a film from the SRB's at tion. There are a few, what look like skid marks in the n the windscreens, although we do not see what put the separation. There are film on the windscreen marks there. the forward Columbia small,

OK, we copy that. Thank you, Dan.

## FILM REVIEW SUMMARY/PROBLEM REPORT DISPOSITION 7.0

which included 70mm 9 and items, 35mm films, film and video data films, 25 35mm fil A total of 118 film and video c videos, 51 16mm films, 25 35mm reviewed starting on launch day.

observed a white tile licle completed 213, 220, 222, that would have affected the mission. However, a white t screed repair fell from the outboard forward corner of the outboard elevon upper surface just before the vehicle complethe roll maneuver (E-52, 57, 210, 207, 211, 211, 213, 220, 223, TV-4, ET-207, ET-212). The screed was later found on pad west of the FSS. An irregular shaped, translucent piece of ice, entering the FOV from above, fell vertically and bounced on the MLP deck sloped ramp without shattering (frame 192 or GMT 12:34:51.433) before falling into the SRB HDP haunch. The object is not symmetric about any axis and is not a metallic washer. Swing arms were already retracted against the FSS and SSME ignition had not yet occurred. However, water deluge on the FSS was activated at T-16 seconds and may have provided enough water flow with the westerly winds to dislodge the ice from the vehicle. Some of that water spray was visible passing by the RH SRB aft BSM's. Later, an ice particle from the ET/ORB LO2 umbilical fell to Later, an ice particle rrom che dick and bounced without shattering in a similar manner.

#1 nozzle during Hydrogen 'lead' was visible exiting the SSME #1 nozzle duri the ignition sequence (19, 20, 76, 77, OTV 71). Red streaks the SSME exhaust plume were caused by pieces of RCS pap covers falling into the plume (E-2).

ration caused small restation caused small restanded shake loose from the base hear tinger (E-17, 18, 20). A refinger (E-17, 18, 20). A refinger (E-17, 18, 20). A refined to the standard restation of the body flap during SSME ignition, but le (E-5, 6, 25, 26, 31, OTV 9, OTV 63). 9, OTV tile damage was heavy shower umbilicals fe shield and tile

An orange GSE tile shim, approximately 4"x1" in size, fell from the RH wing lower surface near the leading edge RCC panels. About 12 particles of white tile surface coating material were shaken loose by SSME ignition from the RH elevon upper surfaces (E-6, 25).

Frangible links between the DCS plungers and the holddown post studs were omitted for this flight in an attempt to eliminate stud hang-ups. However, this change caused a considerable amount of debris to fall from the vehicle during liftoff. One icle during liftoff. One skirt stud hole in E-10, from I hang-ups. However, this change caused a consider nt of debris to fall from the vehicle during liftoff. size object fell from HDP #3 aft skirt stud hole in I large and 11 smaller pieces of frangible nut and ridge from HDP #5 stud hole (EX4, E-12), one object #7 stud hole (E-11), and two objects from the HDP #8. two large and cartridge from

(王-8). (Figure inches shoe was nominal through the HDP covers foot onto aft skirt fell back blast se, and then fell the HDP doghouse partially lifted by the vehicle rise, and then then o£ Closure

damaged slack The arms or The GUCP was not during liftoff. excessive swing Was There were no major facility anomalies. No there vent line latched properly, but there the static lanyard during retraction. vehicle contacted the 50). (E-41, structures lanyard flying shredded sound suppres the pad after the vehicle cleared the tower. SRB throat plug material and shredded sound supported occurrence. amounts of recorded various pad after the vehicle items film and video debris on sion water

movement was apparent. Sensors mounted to the body flap for the sensor location. Extrapolation of the generally of 4.7 inc predicted ascent was partial cloud of the Orbiter body flap during ascent wole due to time of launch, partial cloud trajectory. Although the body flap was with sensor location. Extrapolation of ling edge of the body flap gave an amp ured frequencies compared closely edge of the body flap ga flight data. visible Measured Movement

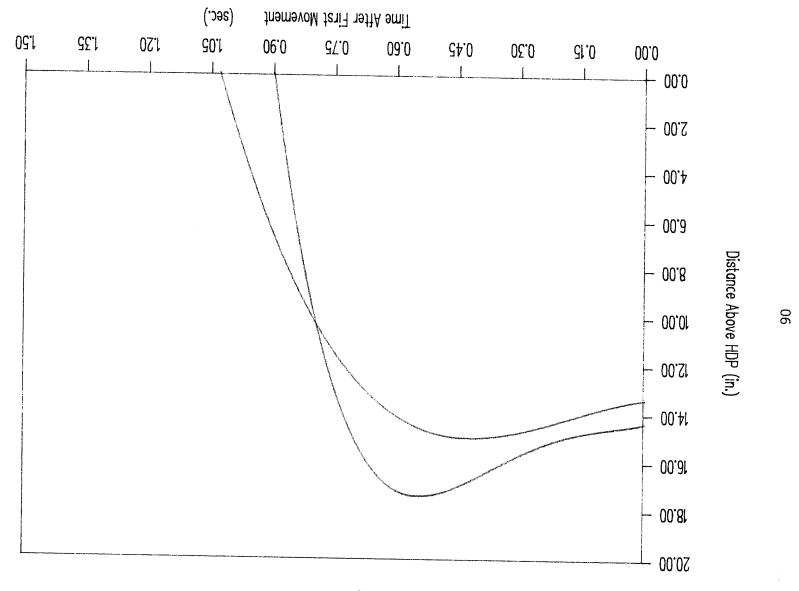
such as RCS paper covers, entering the plume during ascent. such as RCS paper covers, entering the plume. However, one particularly large flash occurred at GMT 12:35:43 (E-204, 207, 213, 218, 220, 222, 223, TV-4). Plume recirculation, a normal occurrence, was visible in E-204, 206, TV-18, ET-206

ET/ORB umbilicals and RCS paper covers from the Orbiter S2, 54, 57, 58, 61). The particles falling from the vehicle at Max Q are either pieces of SRB propellant/inhibitor or aft skirt instafoam (E-207, 223, TV-5). More than 100 the vehicle were visible during ied as ice/frost particles from of which appear very large t, were visible in the SRB varation from the External to and just after separation from the 1905, 207, 211, 223, TV-5, ET-204, ET-207). kirt instafoam (E-207, 223
SRB propellant slag, some of
burning 'blooming' effect, ascent. Most have been identified debris from Numerous pieces of 205, the L.,
(E-52, 54, 5/,
after Max Q are
aft skirt in prior (E-201, chunks of Si due to the plumes

One 35mm and two 16mm cameras in the ET/ORB umbilicals recorded eparation. No anomalies were visible on the ogive The acreage of the intertank was intact except for ivots in the area of the bipods (Figure 13). Two in diameter were located between :o-LHZ tank flange. surrounded the the bipods and just above the intertank-to-LH2 tank flange. third divot 14 inches in diameter was centered between tbipod ramps and extended into the intertank-to-LH2 tank flang. The largest divot, measuring 28 inches wide, surrounded the rive large divots in the area divots measuring 12-14 inches separation. No divots or nosecone. ET large and SRB

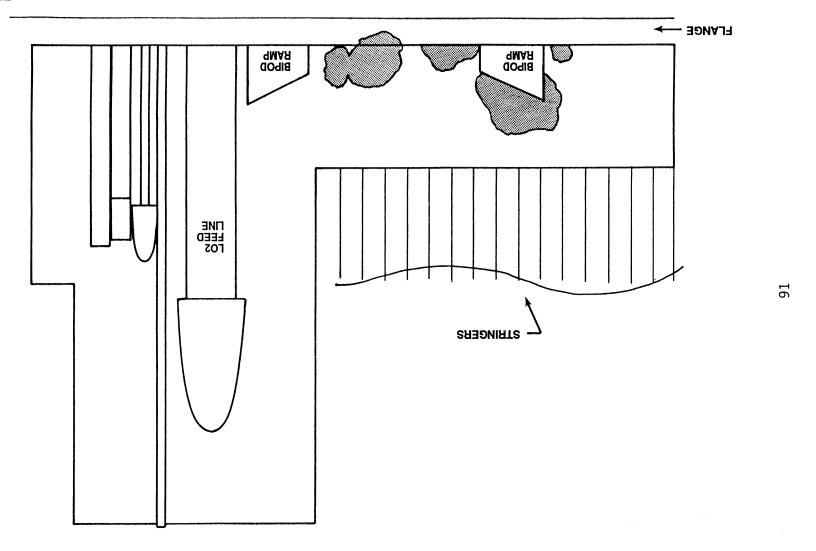
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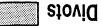
Figure 12: Dog House Closure Data



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## FIGURE 13. STS-32R IN-FLIGHT ANOMALY (STS-32-T-1) Missing Intertank TPS Shown on Post Separation Photos





located outboard tank splice. The foam areas. the umbilical οĘ isochem line. visible The top of the exception of umbilical was damaged and covered with frozen hydrogen. was in good condition with the exception ich was a repair, in the spray abort ar of ET TPS appeared from behind the umbil 11 aft into the field of view. These umbilical was in good condition with the exception of a thin layer of TPS peeled back on top of the umbilical were of view. tank area. greater than the Stringers diameter was LH2 Four large pieces of ET TPS appeared from cable tray or fell aft into the field pieces were the divots from the intertank theabove ramb. a depth gre 6 inches in and just of the LH bipod depth forward part of the L the divots indicating fifth divot measuring tank acreage was ramp LH bipod divots, pieces LH2 umb the LH2 LO2

No PR's or IPR's were generated as a result of the film and video data review. However, the Post Launch Anomalies observed in the Film Review and IFA candidates were presented to the Mission Management Team, Shuttle managers, and vehicle systems in Section engineers. These anomalies are listed

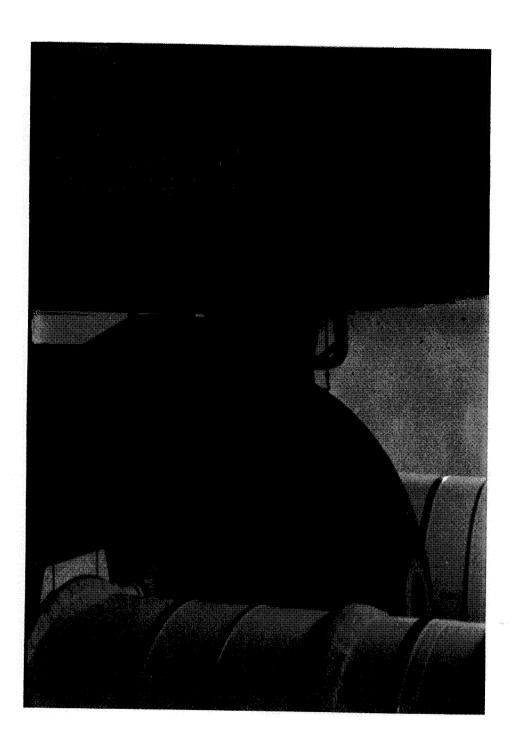
to ignition

just prior

exits SSME #1 nozzle

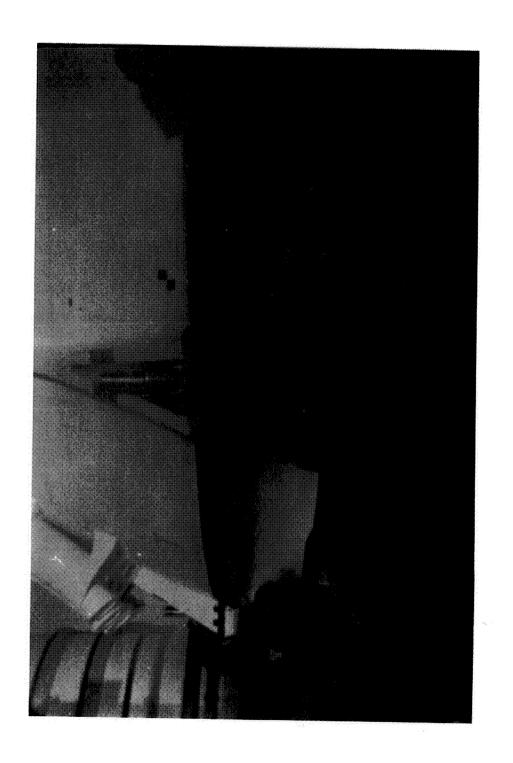
'lead'

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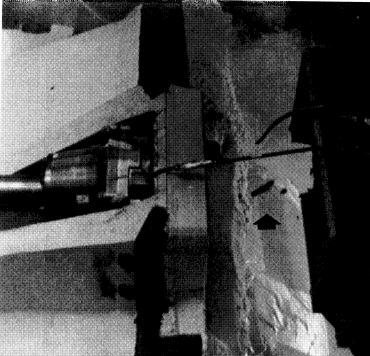
SSME ignition acoustics and vibration cause ice/frost particles to fall from the ET/ORB umbilicals

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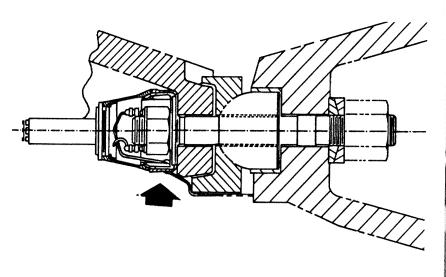


Debonded holddown post #2 shoe shim material is lifted briefly by RH SRB aft skirt, then falls back onto the HDP shoe

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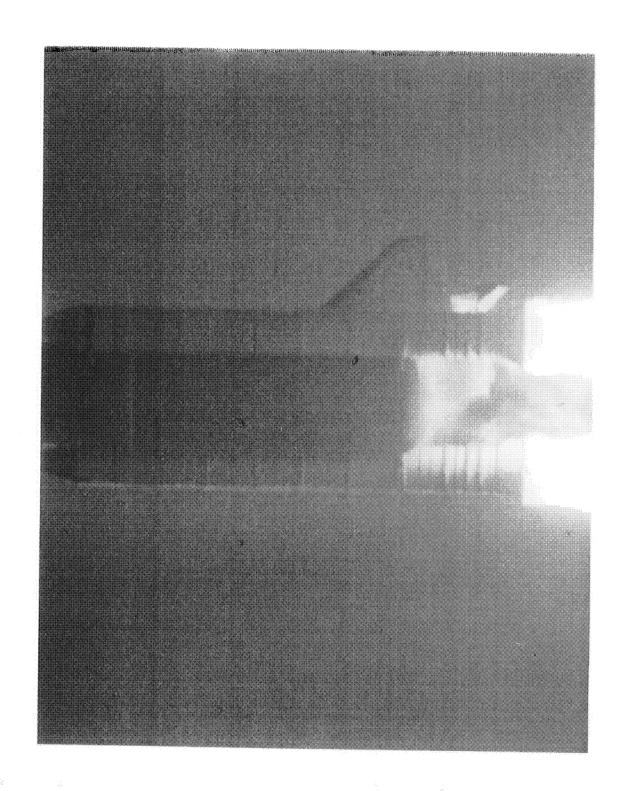






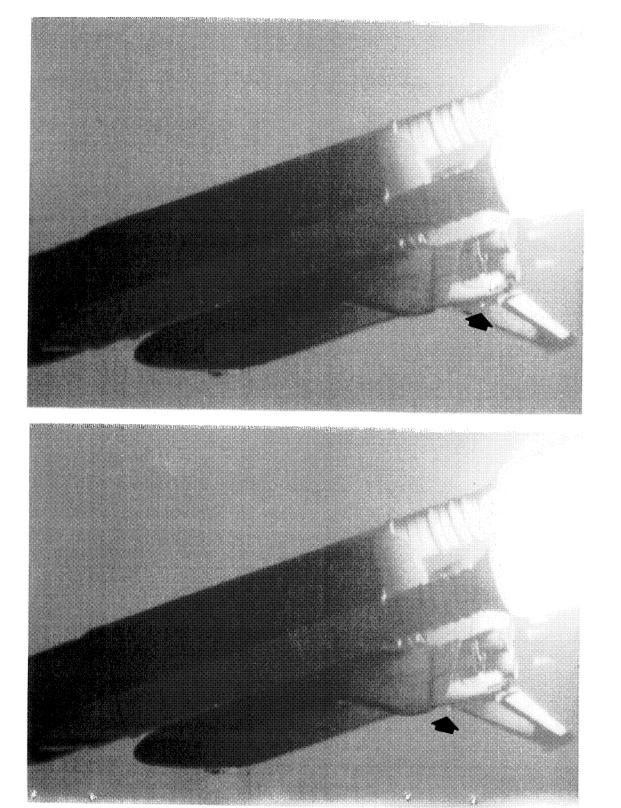
Camera EX4 recorded numerous pieces of frangible nut and NSI cartridge falling from HDP #5 aft skirt stud hole/DCS

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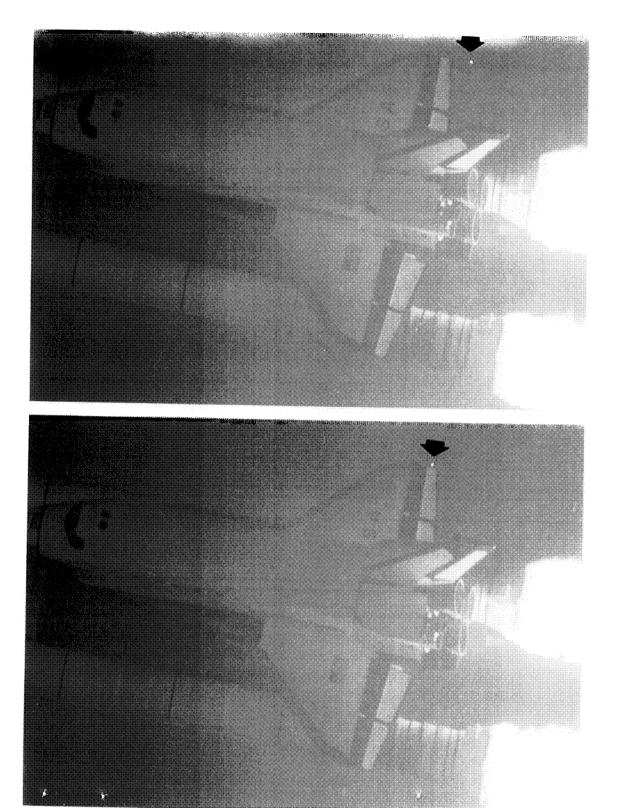
dome and water from SRB normal occurrence aft Backlit view of condensate on ET

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E-207 recorded a piece of white tile screed from the RH out-board elevon falling from the vehicle during the roll maneuver

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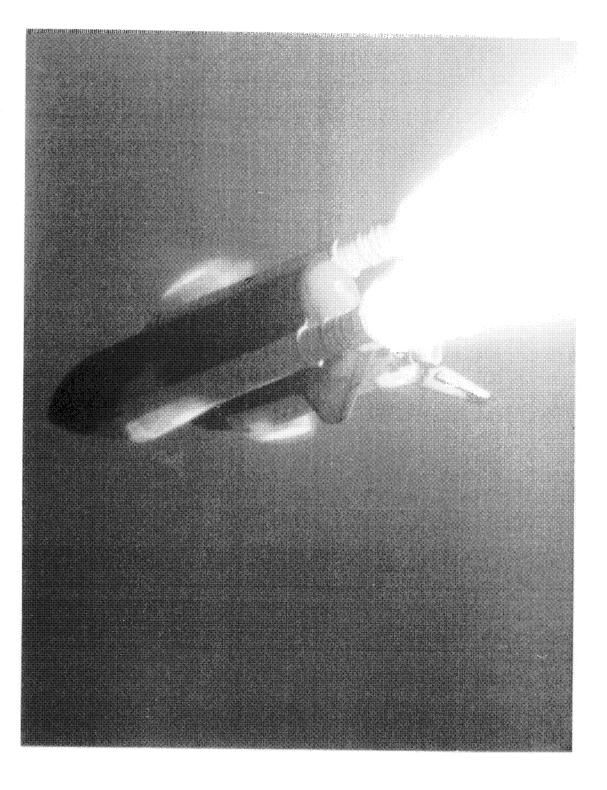


A camera south of the vehicle also recorded the piece of white tile screed falling from the RH outboard elevon

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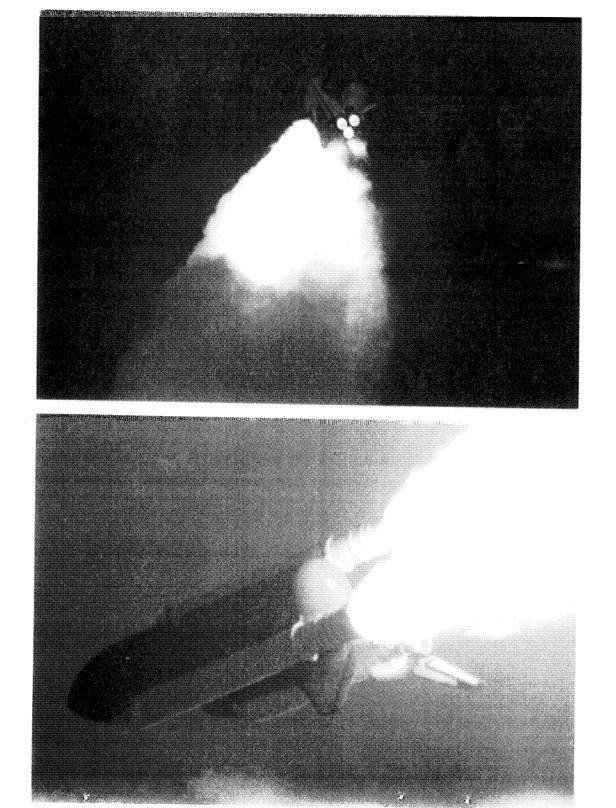
ORIGINAL PAGE COLOR PHOTOGRAPH

supersonic flow condensate typically occurs
in the Max-Q region Appearance of local



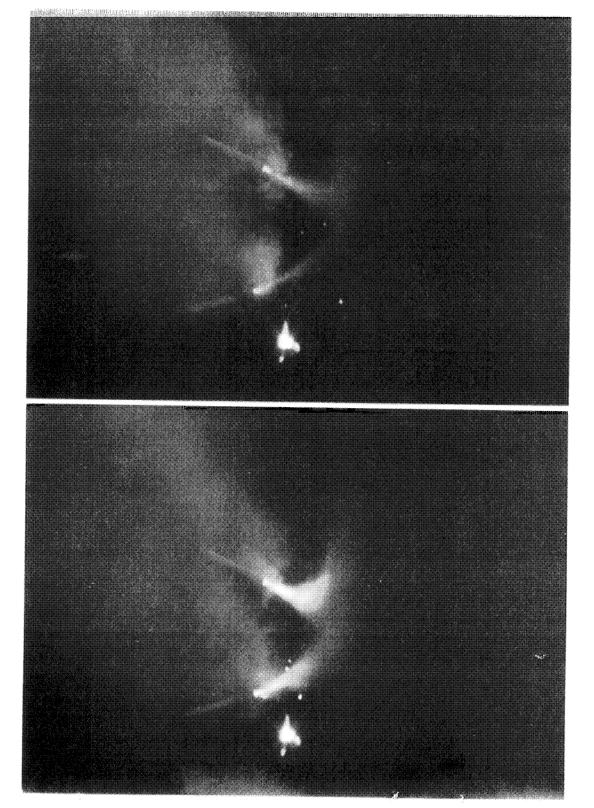
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43 seconds MET A flash occurred in the SSME plume at 101

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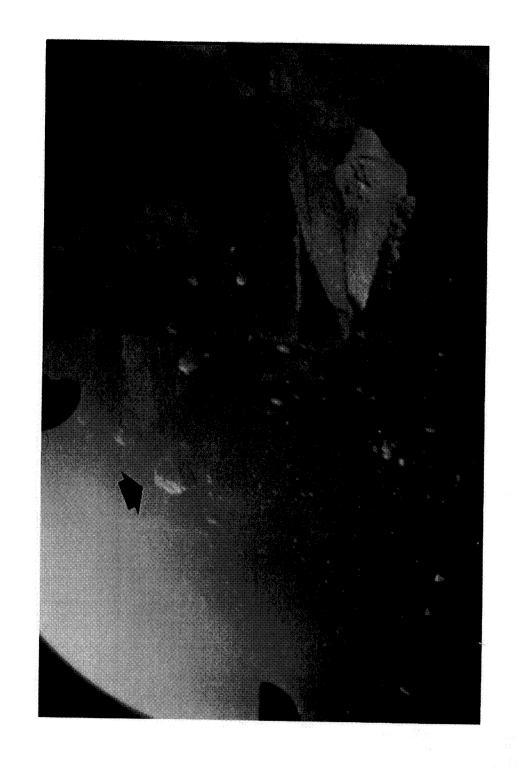


Hundreds of pieces of SRB propellant slag, or clinkers, fall from the SRB plumes before and after separation, a normal event

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ORIGINAL PAGE COLOR PHOTOGRAPH Pieces of ET TPS fall past the LH2 umbilical camera. Note loss of foam from the LH2 umbilical cable tray 103

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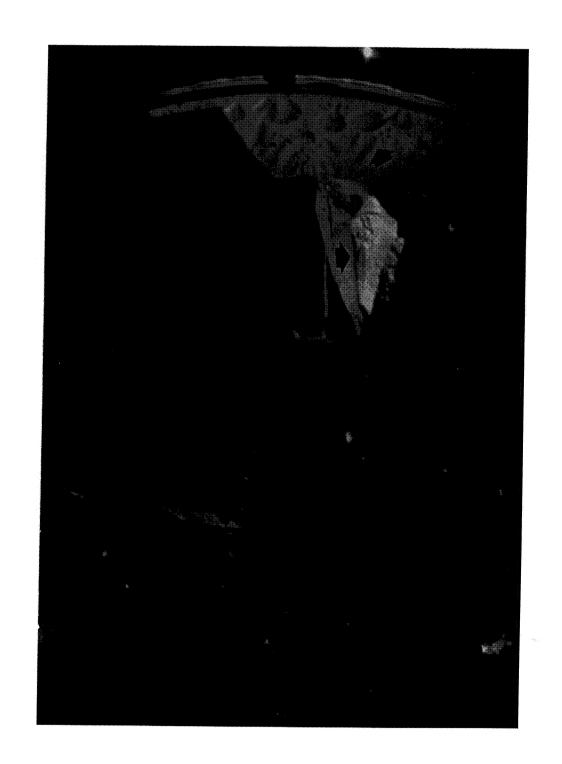


Pieces of TPS from ET intertank divots enter FOV (arrow). Note additional loss of foam from the LH2 umbilical cable tray.

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ORIGINAL PAGE COLOR PHOTOGRAPH

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LH2 umbilical cable tray is missing foam from outboard and aft sides. Fire barrier paint has blistered/bubbled. 105

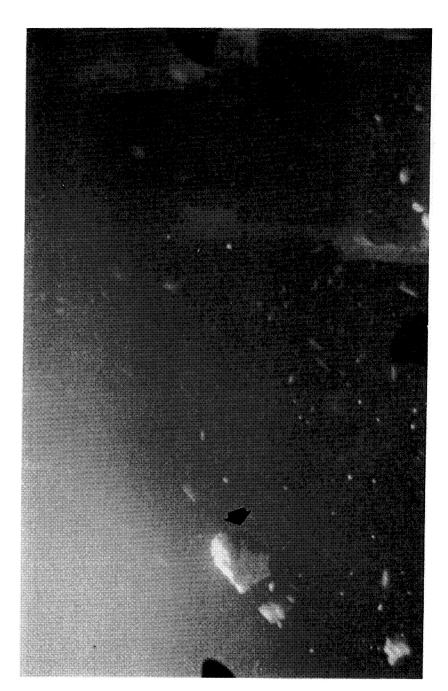
ORIGINAL PAGE COLOR PHOTOGRAPH

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More ET TPS from the intertank divots falls aft past the umbilical camera. Note isochem line in the TPS (arrow).

ORIGINAL PAGE COLOR PHOTOGRAPH

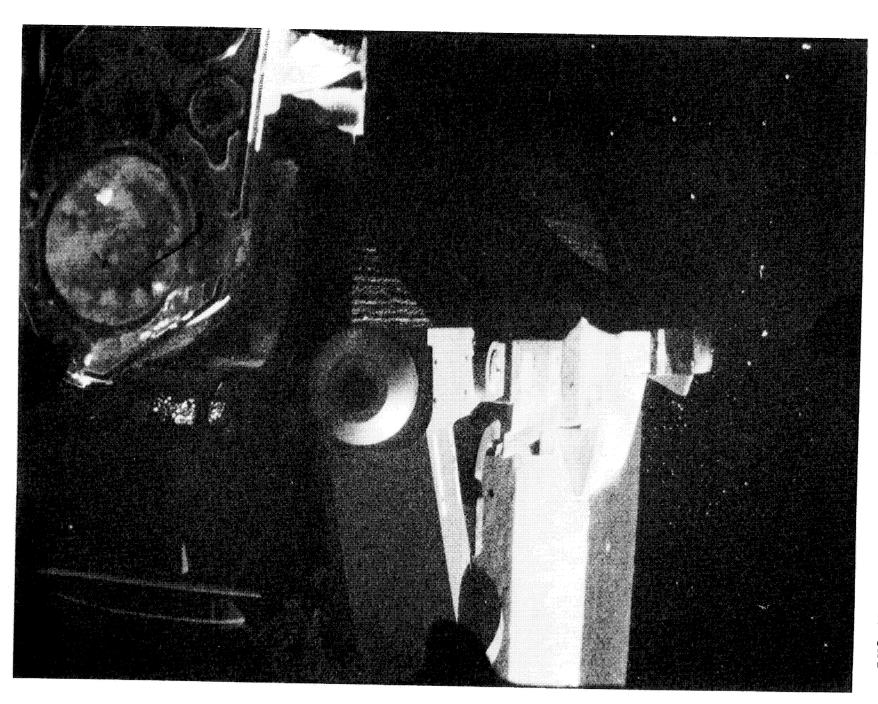
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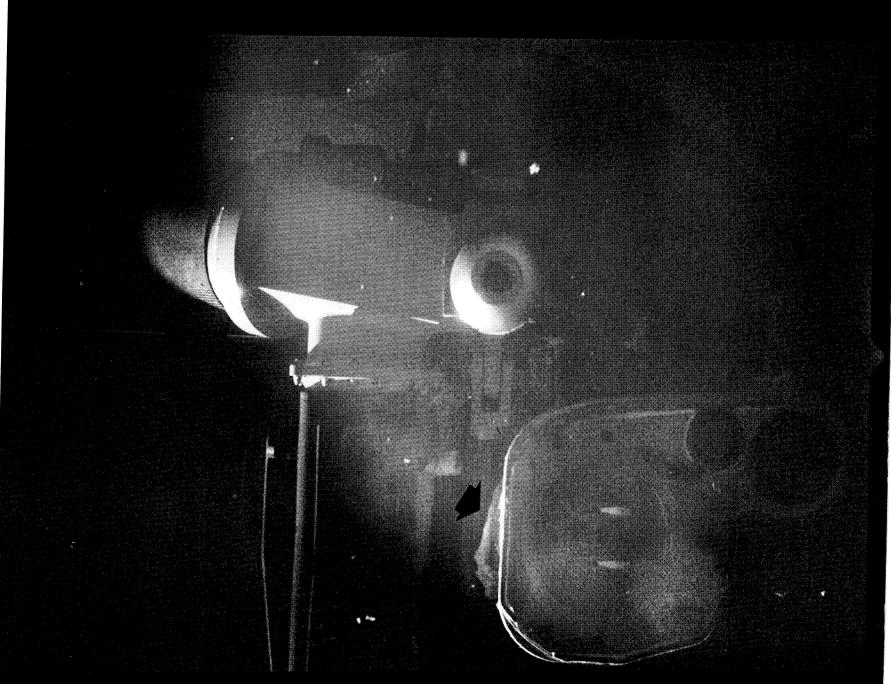
Some of the TPS from the ET intertank divots exhibits dark rind or isochem, as well as structural impressions

**♦** 



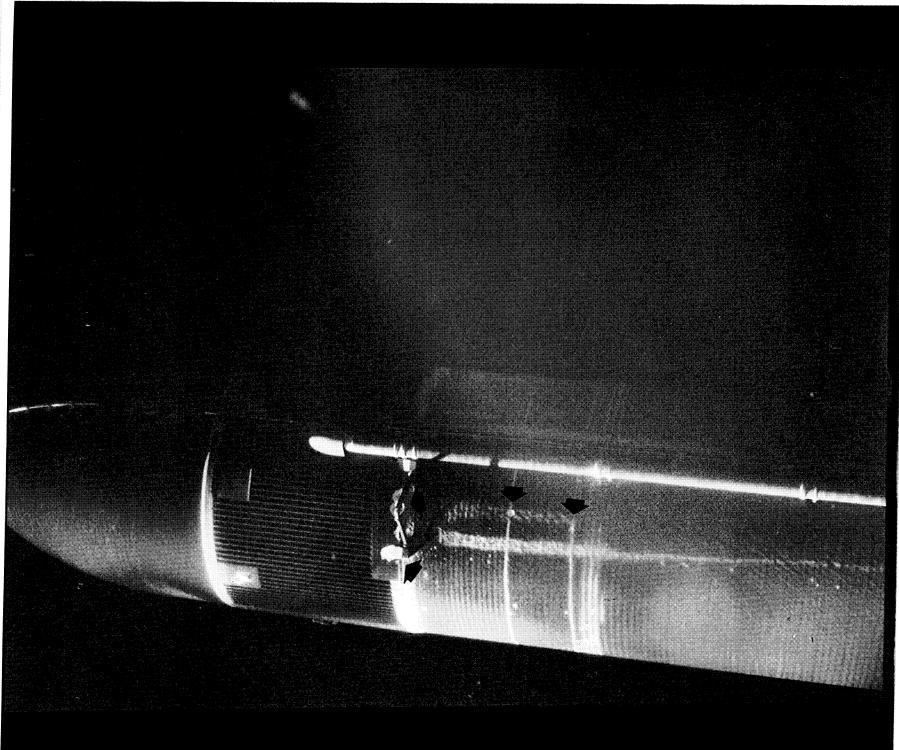
is filled with frozen hydrogen. Top damaged/covered by frozen hydrogen. ORIGINAL PAGE COLOR PHOTOGRAPH 17-inch flapper valve area of umbilical is LH2 1 left

in Si			
₹	*		



Very little damage is visible on +Y side of ET except for TPS peeled back or ice covering on top side of LO2 umbilical ORIGINAL PAGE COLOR PHOTOGRAPH

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Five divots occurred in the intertank TPS forward of the bipods and 2 divots appear on the LH2 tank acreage at the spray aborts

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## 7.1 LAUNCH FILM AND VIDEO DATA REVIEW

## FILM ITEMS

SRB Heater SRB of RH RH to view RE liftoff. south t t ignition and deck and looks north on MLP is located during duct Umbilical exhaust Camera **400 FPS** 16mm

Focus : OK F. O. V.: OK

Exposure: OK

LO2 POSSIBLY A PIECE OF HE INBOARD NORTHERN SHOE JOINT HEATER UMBILICAL APPEARS HOLE ET/ORB OCCURS AT FRAME THROAT THE HDP ND FALLS INTO THE EXHAUST RT STUD HOLE. SRB THROAT THE EXHAUST HOLE. DEBRIS THE FIRES. FROM OF THIN OBJECT, PUR PIECES FALLS T-0ORDNANCE APPEAR BEHIND THE DCA. ICE I AND BOUNCES ON THE MLP DECK. SMALL INSTAFOAM TRIMMING OR SHIM MATERIAL CORNER OF THE SHOE, COMES LOOSE AND FINO DEBRIS FALLS FROM THE AFT SKIRT SRB THE OF IGNITION, A SMALL, OUT ROCKS SLIGHTLY AT LIFTOFF. THE TO SEPARATE PROPERLY. A SMALL, INSTAFOAM TRIMMING OR SHIM MA AND THE DCA OSCILLATES WHEN IS EJECTED UPWARD SSME AFTER Comments: TRIMMINGS UMBILICAL MATERIAL

of RH SRB Heater is located on the MLP deck west and liftoff view t t ignition east and looks during duct Umbilical Camera flame FPS 16mm 400

Focus : OK

F. O. V.: OK

Exposure: SLIGHTLY UNDEREXPOSED

FROM FALL UMBILICAL AWAY DROPS HEATER INSTAFOAM FALL WATER DELUGE JOINT VISIBLE SRB AND FSS WERE OF THE PARTICLES ANOMALIES SSME IGNITION. UMBILICAL ICE SMALL VEHICLE PROPERLY. TO MLP DECK AFTER ET/ORB ON N SKIRT. SEPARATES Comments: AFT

SRB of LH Heater located on the MLP deck east SRB and liftoff view t t west ignition and looks during duct is Umbilical Camera flame FP 16mm EX3 400

Focus : OK F. O. V.: OK

F. O. V.: OK Exposure: OK

FALL JOINT DROPS SRB THE DELUGE VEHICLE ANOMALIES. OF ICE AND FSS WATER SEPARATION 0N IGNITION. ER SSME IGNITIO IS NOT VISIBLE. UMBILICAL DECK AFTER ET/ORB HEATER UMBILICAL Comments: ON MLP

SRB SRB LH south of iew LH liftoff ignition and deck t 0 north located on MLP looks during and duct ۲. د Umbilical Camera flame FPS 400 E 16mm

OK OK Focus

S R Exposure: 0

K5NA PMP PMP SMALLER S FALL FROM THE SRB AFT SKIRT STUD HOLE AS THE VEHICLE TYPICAL QUANTITIES OF SRB THROAT PLUG MATERIAL ARE EJECTED AND DEBRIS AND POST E ORDNANCE IS FIRED. HOLDDOWN POST SEPARATION OF THE SRB JOINT HEATER TWO LARGE AND APPROXIMATELY 11 SM FRAME 4041 OF SMALL PIECES NH OCCURS T-0 ASPIRATION PULLS THE DCA. THE ROCKS SLIGHTLY AT T-0.
BILICAL IS NOT VISIBLE.
BLEET FALL FROM THE STREET BEHIND FROM THE EXHAUST HOLE WHEN SSME FROM OSCILLATES Comments: TRIMMINGS RISES. DCA

deck MLP Orbiter. the oŧ SRB's, and corner NE thelower ET, g located the ٦. ي and views Camera FPS 16mm 400

SOFT Focus

OK R . > o. ĵzi O

UNDEREXPOSED Exposure:

DELUGE WATER FROM HYDROGEN VENT LINE HAUNCH OCCURS START-UP VAPORIZES. 1-0 1-1 SSME AS VEHICLE ASCENDS. 2126. STIFFENER RINGS FRAME AT IGNITION OCCURS SRB OF FOV WATER FROM THE SIDE RIGHT SSME APPEARS NORMAL. THROUGH 4195. Comments: AT FRAME PASSES

deck the MLP nozzles engine οĘ corner OMS SE and theSSME o u located Orbiter i.s and views Camera Щ 16mm 400

S K Focus F. O.

OK >

O K Exposure

DOOR TWO ICE PARTICLES STIFFENER RINGS EXHAUST PLUME COVERS RESIDUAL TSM PAPER LH2 RCS RETRACTION OF LO2 T-0 UMBILICAL. 4168. SRB 1891. STARTING IN FRAME 5129, OCCURS IN FRAME THE IN FRAME FROM IGNITION OCCURS WATER DURING RETRACTION T-0SRB. 4559. AFT. H SSME APPEARS FALL THE IN FRAME NEAR VAPORIZES. TEAR AND VAPORIZES Comments: CLOSURE OCCUR FALL

FPS 16mm 400 E-3

deck the MLP nozzles ψO engine corner and OMS SWon the SSME located Orbiter Camera is views and

NOT RUN ITEM DID FILM Comments

Ø 400 FP

deck the MLP and Orbiter. of corner the NW SRB's, located on ET, lower i.s views Camera

16mm

SOFT

OK N Focus F. O.

UNDEREXPOSED Exposure:

ZH SRB FROM AND OCCURS AT DELUGE WATER INSTAFOAM, SRB EXHAUST HOLES 1-0 1863. L. EJECTS FROM SRI OCCURS IN FRAME THROUGH UPSURGE MATERIAL PASSES OVERPRESSURE AE IGNITION ARM HAUNCH TROUGH 4323. OVERP SUPPRESSION SSME VENT SOUND SUP. Comments: GH2 FRAME

400 FPS

flap, MLP the body οĘ wing, side Orbiter RH east the on and views the lower ET/SRB. located Camera is and deck

and

S S S Focus

:· > o. ٠ تنا

O<sub>K</sub> Exposure:

SSME EXHAUST HOLE OUTBOARD VAPORIZES DURING 096, THROAT PLUG PASSES NEAR THE ANOTHER ICE PARTICLES ORBITER BODY OF AND HOLE. WITHOUT MAKING CONTACT, AND ARE PULLED INTO THE SSME E BY ASPIRATION. ICE PARTICLES FALL FROM THE NOZZLE 4096, ME 4034. INBOARD RESIDUAL LO2 VAPO DURING START-UP. T-0 OCCURS IN FRAME 4034. LOZ VIELEVON MOTION IS APPARENT AT T-0. RESIDUAL LOZ VIRETRACTION OF THE LOZ T-0 UMBILICAL. IN FRAME 405 MATERIAL IS EJECTED FROM THE RH SRB EXHAUST HOLE, 4321. SSME IGNITION OCCURS IN FRAME 1772. I ET/ORBITER UMBILICAL, PASS BY THE OX AKING CONTACT, AND ARE PULLED INTO THE IN FRAME BODY FLAP PASSES NEAR THE Comments: THE PARTICLE FROM

田田 deck body flap, the MLP the RH lower Orbiter wing, body f. feedline, and ET/Orbiter umbilical side of on the east located lower LOX . S and views Camera E-6 200 FPS 16mm

A S S Focus

;; > ó

OK R Exposure: Comments: ELEVON MOTION IS APPARENT AT SSME START. AN ORANGE GSE TILE SHIM (APPROXIMATELY 4" X 1") FALLS THROUGH FOV IN FRAME 1840. NUMEROUS ICE PARTICLES FALL FROM THE ET/ORBITER UMBILICALS. APPROXIMATELY 12 PARTICLES FALL FROM RH WING UPPER SURFACE. T-0 OCCURS IN FRAME 2325. LH UMBILICAL BAGGIE IS LOOSE AT LIFTOFF.

Camera is located on the MLP deck and views the RH SRB northeast holddown post (HDP #4). **400 FPS** 16mm

OK OK Focus o. . Гч

Exposure:

OK

INTO FOV BY IGNITION AND BOUNCES ON THE MLP DECK. ST SHIMS APPEAR INTACT. THE HOLDDOWN POST DOGHOUSE SLOW TO CLOSE. NO DEBRIS FALLS FROM THE AFT SKIRT RTV-LIKE OF A LARGE PIECE DEBRIS IS BLOWN INTO FOV BY IGNITION AND ALL HOLDDOWN POST SHIMS APPEAR INTACT. THE 4125. OCCURS IN FRAME Comments: T-0 DEBRIS IS BLOWN COVER IS HOLE BLAST STUD

and views the (HDP is located on the MLP deck southeast holddown post Camera RH SRB E-8 400 FPS 16mm

OK o. v.: Focus F. O.

OK Exposure:

STAFOAM, THROAT PLUG, AND SOUND SUPPRESSION WATER TROUGH MATERIAL ARE EJECTED FROM THE SRB EXHAUST HOLE AT IGNITION. NO MOVEMENT OF THE HOLDDOWN POST DEBRIS CONTAINMENT ASSEMBLY IS DETECTABLE. PYRO AND THIS FALLS OF DETECTABLE. IS DEBONDED AS THE VEHICLE RISES, DOWN POST. NO DEBRIS TYPICAL AMOUNTS SHOE SHIM THE HOLDDOWN POST. 4151. THE AFT SKIRT FOOT. NORMALLY. THE HDP OCCURS IN FRAME PIECE FALLS BACK DOWN ONTO FROM THE AFT SKIRT STUD HOLE. FALLS BACK DOWN SEPARATES UPWARD BY T-0 Comments: PULLED

400 FPS 16mm

and views (HDP #1). deck southwest holddown post the MLP o located r. S Camera RH SRB

Focus

OK .. .. ó

OK N Exposure:

POSSIBLY A LOOSE MOUNT MUCH CAMERA SHAKE,

THE S NOT A METALLIC THE FSS AND SSME IGNITION HAS NOT YET OCCURRED. HOWEVER, WATER DELUGE ON THE FSS WAS ACTIVATED AT T-16 SECONDS AND MAY HAVE PROVIDED ENOUGH WATER FLOW WITH THE WESTERLY WINDS TO DISLODGE THE ICE FROM THE VEHICLE. SOME OF THAT WATER SPRAY IS VISIBLE PASSING BY THE SRB AFT BSM'S. LATER, AN ICE PARTICLE FROM THE ET/ORBITER UMBILI-MLP DECK AND BOUNCES WITHOUT SHATTERING IN A T-0 OCCURS IN FRAME 3627. SEVERAL PIECES OF ARE EJECTED FROM THE EXHAUST HOLE AT IGNITION. APPEARS FROM BEHIND THE HOLDDOWN POST AND FALLS (FRAME OF ICE, EN SRB HDP HAUNCH. SKIRT SHATTERING TRANSLUCENT PIECE THE THE MLP DECK SLOPED RAMP WITHOUT SHATTI 2:34:51.433) BEFORE FALLING INTO THE SR S NOT SYMMETRIC ABOUT ANY AXIS AND I SWING ARMS ARE ALREADY RETRACTED TO FROM NO DEBRIS FALLS SHAPED, IRREGULAR EXHAUST HOLE. VEHICLE. SOME OF SRB AFT BSM'S. LATER, R T-0 MANNER. T-0 TRIMMING ARE 12:34:51.433) PARTICLE AN FOV NO ΣI Comments: THE ING THE INSTAFAM A DEBRIS SIMILAR BOUNCES WASHER. OBJECT OR GMT

the views (HDP #3). and deck northwest holddown post the MLP o is located RH SRB Camera 400 FPS 16mm E-10

OK OK o. v.: Focus . [14

O K Exposure:

FALLS WATER FROM UPPER LEFT AND OBJECTS, SKIRT SIZE) SUPPRESSION SRB SOUND SUPPRESSI SEVERAL LIGHT-COLORED THE PT ONE OBJECT ENTER FOV BEFORE SIN FRAME 4100. STUD HOLE JUST HOUSE BLAST COVER. BLOWN ACROSS FOV. PLUG MATERIAL, THE EXHAUST HOLE. OCCURS THE DOGHOUSE CORD IS BLOWN SKIRT SRB THROAT 1-0AFT INTO FROM THE Comments: PROBABLY CLEARS TROUGH FALL

400 FPS 16mm E-11

views (HDP #7). and the MLP deck northeast holddown post located on <u>1</u>.8 Camera LH SRB

Focus

Exposure: OK

FOOT. TWO PIECES HOLDDOWN POST ONE OBJECT FALLS FROM THE SRB AF HOLDDOWN POST DOGHOUSE BLAST COVER CLOSES NORMALLY. T-0 OCCURS IN FRAME WATER ASPIRATION. Comments:

the views #5) and (HDP deck southeast holddown post on the MLP is located Camera LH SRB 400 FPS 16mm E-12

Focus : OK

F. O. V.: OK

Exposure: OK

SRB SRB STUD FRANGIBLE HOLE OTHER THE UMBILICALS SKIRT OF D FROM S OF FR AFT SKI EXHAUST OR R PIECES STUD HANG-UP EJECTED PIECES HDP #5 THE ET/ORBITER SSME NUMEROUS THE HOLE AT IGNITION. AT LEAST FOUR CARTRIDGE ARE VISIBLE FALLING FROM THE VEHICLE RISES. NO SIGNS OF STUI ARE LED TOWARDS
AME 3770. N
TRIMMINGS A SIGNS FROM FRAME TRIMMINGS ARE PULLED AND INSTAFOAM AT IGNITION. ICE PARTICLES ZH OCCURS MATERIAL AND T-0 ASPIRATION. ANOMALIES. Comments: INSTAFOAM EXHAUST AS NUT/NSI PLUG

views (HDP #6). is located on the MLP deck and southwest holddown post Camera LH SRB FP E-13 16mm 400

Comments: FILM ITEM DID NOT RUN.

views (HDP #8) and deck northwest holddown post the MLP do located i.s Camera LH SRB FPS E-14 16mm 400

Focus : OK

F. O. V.: OK

Exposure: OK

BE HOLDDOWN POST DOGHOUSE AS-FALL OH OCCURS CONTAINMENT THROUGH THE OBJECTS APPEARS T-0 ONE, PERHALS 1110, E 4348 THROUGH 4385). SHIM MATERIAL WATER DELUGE. OF THE HOLDDOWN POST DEBRIS A LONG NARROW OBJECT PASSES FRAME 4295. ONE, PERHAPS TW CABLE SEPARATES NORMALLY. FSS ON. (FRAME Βĭ SLOW TO CLOSE.

EMENT OF THE HOL STUD HOLE OBSCURED IN FRAME MISSING. NO MOTOR ΗS LEFT SKIRT PYRO S IS S VIEW RIGHT TO THE AFT SI Comments: VI FRAME 4046. PI BLAST COVER FROM

RH  $\mathbf{R}\mathbf{H}$ and theand views troughs, water deck suppression MLP on the SRB skirt, sound suppres lower Orbiter body flap. located Camera is FPS E-15 16mm 400

OK N OK Focus . اعاً

OK .. > Exposure: ·

SUPPRESSION TROUGHS TO GEYSER 20 FEET UPWARD, TWO PIECES OF PIECE OF FACILITY DEBRIS, POSSIBLY FROM INSIDE ONE OF THE TROUGHS, RISES STRAIGHT UP AND FALLS BACK INTO THE EXHAUST BUT IS NOT NEAR THE VEHICLE (FRAME 3616). THROAT PLUG AL RISES UPWARD THROUGH UPPER LEFT CORNER OF FOV. NO DEBRIS FROM THE AFT SKIRT STUD HOLES. HDP #3 DOGHOUSE COVER CLOSES OCCURS NORMAL. URS IN FRAME 1257 AND ALL. T-0 OCCET/ORBITER LOZ UMBILICAL. T-0 OCCTOTOR TRESTER IN THE HOLE, BUT IS NOT NEAR THE VEHICLE (FR MATERIAL RISES UPWARD THROUGH UPPER LEFT FALLS FROM THE AFT SKIRT STUD HOLES. HDP TROUGHS, RISES STRAIGHT C. BUT IS NOT NEAR THE VEHICLE ICE PARTICLES FALL FROM THE ET/O IN FRAME 3562. SRB OVERPRESSURE OCCURS INSTAFOAM APPEAR FROM BEHIND SSME IGNITION Comments: PROPERLY. WATER SOUND RIGID

SRB

ΤH and the and views troughs, sound suppression water deck Camera is located on the MLP skirt, sound suppres ir Orbiter body flap. lower SRB E-16 400 FPS 16mm

O N O Focus F. O.

Exposure:

OK K

LL FROM THE ET/ORBITER LH2 UMBILICAL AT IN FRAME 4864. SRB OVERPRESSURE UPSURGE APPEARS NORMAL. DOGHOUSE START-UP TO GEYSER IN THE SRB SOUND SUPPRESSION TROUGHS TO GEYSEF PARTICLES OF INSTAFOAM AND WATER TROUGH MATERIAL POST SSME HOLDDOWN 2534 AND DURING THE Comments: SSME IGNITION OCCURS IN FRAME ORBITER BODY FLAP MOTION IS APPARENT NUMEROUS ICE PARTICLES FALL FROM THE ET/SSME IGNITION. T-0 OCCURS IN FRAME 4864. CAUSES WATER IN THE SRB SOUND SUPPRESSI HOLE. EXHAUST CLOSE NORMALLY. SRB THE EJECTED FROM FEET UPWARD. COVERS

views the and TSM and deck T-0 Umbilical on the MLP of the LO2 located ٦. د side Camera Ø 딘 E-17 16mm 400

OK Focus

OK F. O. V.:

OK Exposure:

TEAR FLAP ORBITER BODY COVERS UMBILICAL PAPER RCS 5415. ET/ORBITER START-UP. SSME IGNITION OCCURS IN FRAME APPARENT DURING SSME START-UP. THE SSME FROM PARTICLES SSME HCE MOTION IS AND FALL. Comments:

RETRACTION ORBITER ALTHOUGH A OF THE RH THE ON THE AFT FACE N FRAME 9885. T-0 UMBILICAL CONDENSATE IGNITION. CONDENSATI-0 OCCURS IN FRAME 102 CHIPPED IS RELEASED, T-0A FEW TILES ARE AT RAIN LINE FALL AT SHIELD VAPORIZES. GOX QUANTITY OF NORMAL. STINGER DRAIN HEAT POD APPEARS LARGE

views TSM. and and deck T-0 umbilical on the MLP LH2 located the οŧ ب ي side Camera 2 FPS 400

the

Focus : SLIGHTLY SOFT

F. O. V.: OK Exposure: OK

TER LH2 UMBILICAL ORBITER BASE HEAT DRAWN AFT BY COVERS NORMAL. START-ASPIRATION. ONE TILE IS CHIPPED ON THE ORBITER BASE HEAT SHIELD. SSME PAPER RETRACTION (FRAME 2357) APPEARS DURING T-0 RETRACTION AND IS DRAW DURING RCS THE ET/ORBITER ZES ON THE ORBI 2357. APPARENT SSME IGNITION OCCURS IN FRAME VAPORIZES S FROM RETRACTION MOTION PARTICLES CONDENSATE BODY FLAP T-0 UMBILICAL LH2 VAPORIZES ICE IGNITION. ORBITER FALL. Comments: AND LH2 UP. LHZ RESIDUAL SHIELD. TEAR

deck aft the MLP Orbiter side of and the SSME/OMS nozzles SE on the located shield area. <del>ا</del>. views Camera heat FPS 16mm 400

Focus : OK

F. O. V.: OK Exposure: OK

ICE START AROUND T-0 UMBILICAL. QUANTITY NUMEROUS VAPOR VAPORIZES UMBILICAL RETRACTION SSME LO2 T-0 FALL. IGNITION. THE AND NORMAL. SME #1 WATER AND TEAR SSME S FALL FROM THE SSME NOZZLES UMBILICAL RETRACTION APPEARS 1-0 ATMOSPHERIC LEAD PRECEDES DURING RESIDUAL LO2 VAPORIZES DRAWN AFT BY ASPIRATION. FRAME 2012. NOZZLES. RCS HYDROGEN Z PARTICLES Comments: SSME T-0 OCCURS 102

deck aft the MLP and Orbiter of side located on the SW sic the SSME/OMS nozzles shield area. j. and views Camera heat 400 FPS E-20 16mm

OK OK o. v.: Focus

Exposure:

PLANE. ATMOSPHERIC WATER S. AN INSTRUMENTED TILE FRAME COVER IGNITION HEAT SPOT) IS VISIBLE ON THE RH OUTBOARD ELEVON UPPER LH CORNER. D ICE OCCURS A: FION IS NORMAL. STINGER ASPIRATION. FOUR TILE DINGS ON THE BASE #1 AND #2 AND ONE ON THE LH RCS STINGE! A COUSTICS. A PIECE OF TORN RCS PAPER SSME UMBILICAL AT FRAME 1964. RCS PAPER COVERS TEAR AND IC T-0 UMBILICAL DURING SSME IGNITION. T-0 OCC LH2 T-0 UMBILICAL DISCONNECT AND RETRACTION IGNITION. SSME #1 IGNI: COVERS TEAR E IGNITION. T THE NOZZLES. #1 NOZZLE EXIT FROM VAPORS SSME HYDROGEN LEAD PRECEDES ALL RESIDUAL SSME AROUND WEEN SSME IGNITION FLUTTERS JUST ABOVE ΒX OF VAPORIZES INTO THE PLUME SHIELD BETWEEN NORMAL AMOUNT LH2 ВХ AT Comments: THE LH2 OCCURS CAUSED VAPOR (DARK 4234.

TSM and views umbilical. 102 T-0 theof the inside the disconnection is located Camera **E-21** 200 FPS 16mm

S K Focus

OK ; > ° O

OK Exposure:

FLEXLINES RAME 4414. RESIDUAL LO2 AND IS DRAWN AFT BY SSME UMBILICAL APPEARS AN INSECT WHICH CLEARED AN OBJECT, PIN THROUGH ONE END, TO BE A PIP-PIN WITH A COTTER PIN THROUGH ONE ENIFOV JUST PRIOR TO END OF ITEM AFTER VEHICLE HAS TION. SEPARATION AND RETRACTION OF THE UMBILICA THROUGH FOV SHORTLY AFTER DOOR CLOSURE. AN OBJE UMBILICAL I - 0IN FRAME SSME START-UP. T-0 OCCURS IN FI ES AS THE T-0 UMBILICAL SEPARATES ION. SEPARATION AND RETRACTION O THE FROM FALL PARTICLES ICE ASPIRATION. THE TOWER. Comments: APPEARS THROUGH NORMAL. DURING

TSM and views umbilical Camera is located inside the LH2 T-0the οĘ disconnection E-22 200 FPS 16mm

Focus

OK 0. ♥.:

OK N Exposure:

PURGE BARRIER UMBILICAL NOR-2194. UMBII DOOR CLOSES IS HANGING ACROSS FOV INSIDE TSM. OCCURS IN FRAME TSMNORMAL. IGNITION. T-0 OCCU CABLE AND SSME SEPARATION Comments: FALLS AT

CAMERA CLOSURE. THE OF AFTER DOOR CABLE HANGING IN FRONT FOV OF -0-SIDE SHORILY AFTER T AND DOES NOT REBOUND. LEFT THROUGH WITH SMOKE AROUND WHIPS FILLS MALLY

and views deck on the MLP nozzle. is located engine OMS Camera FPS 1.6mm E-23 400

the

Focus : OK F. O. V.: OK

Exposure: OK

102 102 BURNING VIBRATES SSME VAPORIZES AROUND VIBRATION/MOVEMENT THAN USUAL. SSME ASPIRATION. RESIDUAL THE FREE NOZZLE FALL. 1 BOTH THE LO2 T-0 UMBILICAL AND ATMOSPHERIC WATER VAPOR VAPORIZ 2153. AND 4240. THE SSME NOZZLES. T-0 OCCURS IN FRAME 4240. VAPORIZES UPON T-0 DISCONNECT AND IS DRAWN AFT BY OMS NOZZLES. C FRAME ИH PAPER C OCCURS ICE PARTICLES FALL FROM BOTH THE MORE SEAL DRAIN LINES. ATMUSE. RCS P EXHIBITS IGNITION CLOSES NORMALLY OUTSIDE N BURNS OUTSIDE SSME START-UP. INSULATION EXH SSME Comments: HYDROGEN DOOR HATBAND 102

deck and views the is located on the MLP nozzle engine Camera LH OMS 400 FPS E-24

16mm

Focus : OK

F. O. V.: OK Exposure: OK

LO2 T-0NOZZLE DISCONNECT FROM THE AND FALL. THE SSME NOZZLES. OMS FROM TEAR FALL VAPORIZES UPON T-0 2267. FALL 1 RS IN FRAME 2267.
ICE PARTICLES FALL
RCS PAPER COVERS IS AROUND THE SSME ICE PARTICLES VEHICLE RISES. VIBRATES DURING SSME START-UP. ICE T-0 UMBILICAL AND SSME #1 NOZZLE. RC ATMOSPHERIC WATER VAPOR VAPORIZES A OCCURS IN FRAME 4335. RESIDUAL LH2 VAND IS DRAWN AFT BY ASPIRATION. I ET/ORBITER LH2 UMBILICAL AS THE VEHI OCCURS IGNITION SSME Comments:

400 FPS 16mm

and liftoff the MLP the east side of the and ET/SRB during the views between Orbiter ono is located Camera

Focus

HIGH SLIGHTLY HIG ;; > ó

Exposure:

IS AP-ELEVON THEN PASSES PASS PAR-AND PARTICLES PARTICLES THE A PARTICLE ORBITER WING AN ELEVON MOTION SOUTH. PARTICLE COVERS FALL AFT 1803, OCCURS IN 1332. IN FRAME 1800 OF FOV NEAR THE ORBITER WINGTHE RIGHT OF FOV. ELEVON MOTOUP. A PARTICLE FALLS BETWEEN ICE 10 SOT NUMEROUS IN FRAME 3814. RCS PAPER AND TOP OF TSM IN FRAME 2511. NUMER I THE ET/ORBITER UMBILICALS. IN FRAME SS THE TOP OF THE FOV FROM NORTH TO PARENT DURING SSME START-UP. LEFT PART THE MLP DECK IN IGNITION 4269. RH WING SSME IN FRAME ZI TICLE RISES omments: OL THE VEHICLE ACROSS FALLS FROM

Camera is located on the west side of the MLP an views between Orbiter and ET/SRB during liftoff. Camera is located on FPS E-26 400 E 16mm

SOFT Focus

TOO HIGH

UNDEREXPOSED F. O. V.: Exposure:

3429. QD AS VENT PARTICLES FALL FRAME 1350. ICE PARTICLES DELUGE WATER FROM THE GH2 FLIGHT FRAME Z RESIDUAL HYDROGEN VAPOR TRAILS FROM THE ORBITER LH2 OCCURS 1-0 IGNITION OCCURS IN FRAME FOV. 'ORBITER UMBILICAL. THE THROUGH VEHICLE ASCENDS. LH2 ET/ORB] NCH PASSES SSME Comments: SS FROM THE LH2 LINE HAUNCH 1

SRB views RH cover. blast and deck #3) k on the MLP nost (HDP located on the Camera is northwest ß FP 16mm E-27

었 Focus

OK F. O. V.: Exposure:

OK

SHAKE EXCESSIVE CAMERA Note

PLUG HOLDDOWN THROAT 4389. OF A LARGE PIECE FRAME TO CLOSE. HOLE IN IN FRAME 4055. #3 DOGHOUSE BLAST COVER IS SLOW SRB EXHAUST OCCURS IN INTO THE 0-L FALLS Comments: MATERIAL POST

LH COVER views c and v blast deck #7) MLP (HDP located on the holddown post Camera is northeast FPS 16mm E-28 400

O K Focus

OK OK ;; > Exposure: o. ە ئىزا

PARTICLE FALLS FROM HOLDDOWN POST #8 AFT SKIRT STUD ME 4456. SHIM MATERIAL APPEARS TO REMAIN BONDED TO AFT HOLDDOWN POST DOGHOUSE BLAST COVER CLOSES PROPERLY. FSS W SKIRT AND ANGLE SUN D T DOE DEGRADED VISIBILITY DELUGE. ONE PARTICLE HOLE IN FRAME 4456. S FOOT Comments: SKIRT

troughs and level sound suppression water foot 195 is located on the FSS and SRB TH Camera views 400 FPS E-30

O K Focus

OK ; > Exposure: F. O.

UNDEREXPOSED

FSS O.E DOE VISIBILITY DEGRADED Comments:

SSME FROM WATER DELUGE FALL PARTICLES 4110. IN FRAME HCE OCCURS 1978 FRAME T-0 UMBILICALS. ZH OCCURS IGNITION CET/ORBITER

and level and flap, foot the FSS 95 wing, body ical area. umbilical located on LH Orbiter LH2 views the I ET/Orbiter Camera is 100 FPS E-31

S K Focus

었 F. O. V.: Exposure:

UNDEREXPOSED

VAPORS FALL FROM THE ET/ORBITER UMBILICALS AT SSME IGNITION AND PASS BY THE BODY FLAP WITHOUT CAUSING TILE DAMAGE. IN FRAME 978, A SLOW MOVING 2" X 4" PARTICLE FALLS FROM THE ET/ORBITER LO2 UMBILICAL CABLE TRAY. ELEVON MOTION IS APPARENT DURING SSME STARTUP. T-0 OCCURS IN FRAME 1625. CONDENSATE VAPORIZES ON THE ET AFT WATER PARTICLES AND ATMOSPHERIC ICE FRAME 823. #3 NOZZLES. AROUND SSME #2 AND #3 NOZZLES. M THE ET/ORBITER UMBILICALS AT IN FRAME IGNITION OCCURS SSME Comments: SSME VAPOR VAPORIZES DOME.

**E-33** 200 FPS 16mm

and level foot and GUCP 235 the FSS line vent ono located ET GH2 v the <u>1</u>.8 Camera views

> 엉 Focus

OK O<sub>K</sub> ÷ : Exposure:

AREA APPROXIMATELY ICE/FROST FORMED T CARRIER A SWATT PLATE. A SMALL K STRINGER NEAR FLIGHT "WALKS" ARM, AROUND THE PERIMELLA, CARRIER PI
ON THE GROUND UMBILICAL CARRIER PI VIEW OBSCURED BY FSS DELUGE WATER. VEHICLE 5088. IS ALSO PRESENT OCCURS IN FRAME TO THE NORTH. Comments: VIEW OF THE GH2 VENT ARM, OF ICE/FROST 1-0 AND SPLICE. 14 FEET SEMBLY,

located views upper Camera is E-34 300 FPS 16mm

and

level

foot

255

at

r FSS tile

Orbiter

0

surfaces.

SOFT Focus

SLIGHTLY UNDEREXPOSED 0 况 F. O. V.: Exposure:

WATER HYDROGEN FIRE DETEC-INTACT AS THE VEHICLE DELUGE NORMAL. HYDENOTORY FACILITY FRAME 2123. APPEARS NORM STRUT IS STI FRAME SEPARATION ON THE ET ZH OCCURS PAPER GUCP 0-L CROSSES FOV. BUTCHER Comments: TION BUT ASCENDS.

and level foot 255 fo located on the FSS mid-Orbiter/ET/SRB is the Camera views FPS E-35 300 F 16mm

SOFT Focus . Би

TOO FAR RIGHT cus :

UNDEREXPOSED SLIGHTLY SLIGHTLY Exposure:

LST BY WESTERLY WINDS. SCURS IN FRAME 2203. NO DEBRIS OR VEHICLE BLOWN EAST BY WESTERLY OCCURS FEET. T-0632. X 20 HS OBSERVED THROUGH LOV. AS IN FRAME 6. APPROXIMATELY WATER FACILITY DELUGE IGNITION OCCURS LE WALKS NORTH AP ANOMALIES ARE Comments: VEHICLE SSME

trough and level and water foot 255 FSS 255 SRB's, theET, on Orbiter, located views lower 1.8 Camera FPS 300 E 16mm E-36

Focus

O K 0. ∀.: بر بر

UNDEREXPOSED Exposure

PEARS NORMAL. GH2 VENT ARM RETRACTION ALSO APPEARS NORMAL. AFTER VEHICLE LEAVES FOV, A PARTICLE WEST OF THE LH2 TSM FALLS FROM THE NORTH (FRAME 3314). IN FRAME 3425, ANOTHER PARTICLE FALLS FROM THE NORTH TO THE WEST OF THE LH2 TSM. IN FRAME SUPPRESSION TROUGHS IGNITION OVER UMBILICAL DISCONNECT AND RETRACTION OCCURS IGNITION OCCURS IN FRAME 827. T-0 C SUPPRESSION WATER TROUGHS REACT TO SE AND WATER IN THE SOUND SUPPRE UPSURGE AND WATER T-0 LH2 SOUND GEYSERS UPWARD. Comments: 2525. SRB PRESSURE

foot level is located on the FSS 185 GH2 vent line latchback. Camera views 300 FPS 16mm

DELUGE WATER FSS OBSCURED BY Focus F. O.

IGNITION UNDEREXPOSED UNTIL MPS Exposure:

BY DELUGE RETRACTED LINE WAS OBSCURED DARK UNTIL GH2 VENT PEARS, IT IS QUICKLY AND LATCHED. WHEN IMAGE APPEARS, IT WATER AND SRB PLUME. NO USEFUL DATA. COMPLETELY VIEW Comments:

level and Orbiter and is located on the FSS 275 foot nosecone, SRB ET ogive, tiled surfaces. the Camera views 300 FPS 16mm E-40

O<sub>K</sub> Focus

S K

UNDEREXPOSED F. O. V.: Exposure:

WATER SPEED COLDER IN FRAME LEAD-STABI-CONTINUE 日日 PAST BRAKE. A WHITE OBJECT FIRST APPEARS IN FRAME 3725 NEAR THE ING EDGE OF THE LH OMS POD AND MOVES PAST THE VERTICAL 3 SRB STIFFENER RINGS VAPORIZES. TO THE TO BE T-0 OCCURS SOUTHEAST VAPORS NOSECONE FAIRING. VEHICLE TWANG LOOKS NORMAL. T-0 OC 2450. GOX VAPORS INCREASE AT LIFTOFF AND CONTINUE DOE VAPORS/CONDENSATE EMANATE FROM THE SPLIT IN RESIDUAL BLOWING S LOUVER. THE VEHICLE. VISIBLE COVERS E ASCENDS. NO TPS WATER FROM THE SP NEAR THE GOX VAPORS ARE LIGHT FROST 2450. GOX VELCE ASCENDS. IS NOT BUT Comments: DOME AND WEATHER, LIZER,

MUCH FACILITY ICLE CLEARS THE THE VEHICLE ASCENDS. MUCI OV WELL AFTER THE VEHICLE NT HOOD WINDOWS). GOX VENT HOOD FOV AS THE ΩŎ THROUGH (SOME PIECES OF FLIGHT EXIT THE LH2 DEBRIS PASSES TOWER

Also aft foot level SRB rotation and during rot structure 255 the FSS line clearance between go GH2 vent located ٦. ي the Camera views shows 300 FPS 16mm

and

O K Focus

UNDEREXPOSED OK ·· : Exposure: o ٠ تتا

NT LINE FOV T-0GUCP. THROUGH GH2 VENT DEBRIS AROUND THE FACILITY DEBRIS PARTICLES FALL VEHICLE CLEARING TOWER. THE GH COMMEDICS.

OCCURS IN FRAME 2368. FACILITY DEBALS

FROM ABOVE PRIOR TO VEHICLE CLEARING TOWER. THE

FROM ABOVE PRIOR TO SOME SLACK. MORE FACILITY CONDENSES WATER VAPOR ATMOSPHERIC Comments:

and foot level deceleration, 185 drop, on the FSS line vent located GH2 i. S the views the latchback Camera 300 FPS 16mm

Focus

**;** 0

Exposure:

THEN JAMMED SHORT TIME, FILM ITEM RAN FOR A Comments:

foot level tiles edge 155 the FSS leading OMS Pod liftoff. on is located the LH and ignition Camera views 300 FPS 16mm

OK Focus

S N OK o. v.: Exposure . Щ

HYDROGEN VAPOR STREAMS RCS PAPER CONDENSATE FROM THE RUDDER SPEED BRAKE SPLIT AS THE VEHICLE RISES. COVERS TEAR AND FALL. NO ORBITER TPS ANOMALIES. RESIDUAL WATER AND 2081. g IN FRAME ORBITER LH2 FLIGHT OCCURS T-0 FROM Comments: TRAILS

GH2 (ET rotation, the foot level and views disconnection, 215 structure) on the FSS GUCP arm located during access line Intertank latchback Camera vent E-48 300 FPS 16mm

Focus

o. V.:

UNDEREXPOSED Exposure:

NO EXPOSURE PROBLEMS. VAPORIZES CONDENSATE FLIGHT SRB STIFFENER RINGS THE T-0. ON AT DETAILS OL GUCP DOE 2158. FALL FROM THE T-0AFT DOME AND WATER FROM THE RIER PLATE ARE NOT VISIBLE AT FRAME ZH PARTICLES OCCURS RISES. 1-0 VEHICLE SEVERAL ICE Comments: THE ET THE

line at NE vent latchback. site 1 GH2 camera entire and rotation located at views and during Camera is perimeter GUCP durir 60 FPS 16mm

OK 엉 > Focus ó ъ.

OK R Exposure:

THE NORMAL. RETRAC-GUCP. SLACK, DURING LINE ROTATION APPEARS THE THE ATMOSPHERIC WATER VAPOR CONDENSES AROUND FRAME 2943. GH2 VENT LINE COLLECT STATIC LANYARD EXHIBITS EXCESSIVE SLACK STATIC TATCHED IN FRAME 3505. DUE TO CABLE LOOPS AS THE ARM LATCHES. VENT LINE TION. VENT LINI STATIC LANYARD OCCURS IN VENT LINE Comments: TION

pad of one-third east feet. the o u lower 1200 N site t t οĘ from ignition Camera is located at camera tracking Remote vehicle perimeter. launch veh 96 FPS 35mm **E-52** 

OK Focus F. O.

OK

OK R Exposure:

OF ICE PIECES AT SRB BY FROM CRYO OF AN RCS PAPER ASCENT. THROWN NORTH FLAP HOLE WATER IN THE PARTICLES FSS AND MLP FALL AS THE VEHICLE CONTINUE TO FAL.
AS THE VEHICLE RISES. TWO PIECES
FRAMES 70-11 AND 71-14. NUMEROUS
FROM THE VEHICLE DURING EARLY ASC BODY EXHAUST ICE/FROST I L PAST THE PLUG MATERIAL ARE THE COMBUSTION ET AFT DOME AND SSME FALL FROM THE ET/ORBITER UMBILICALS FALL THE NORMAL. OLNI CAUSED BY IGNITION APPEARS PULLED PARTICLES OF THROAT ICE/FROST PARTICLES CONDENSATE ON THE FROM RINGS VAPORIZES. FITTING IN THE ET/ORBITER UMBILICALS COVERS FALL SSME PLUME, AND ARE THE SSME IGNITION FALL FROM EB-8 T-0. RCS PAPER Comments: S ASPIRATION. IGNITION. STIFFENER LINES AT SSME

FROM COMPLETION FLAP MOTION FALLS TILE THE BODY BEFORE OR WHITE CHARRING APPEARS IN FRAME 91-12. A PIECE OF OUTBOARD ELEVON UPPER SURFACE JUST ROLL MANEUVER. NO ET AFT DOME RENT DURING EARLY ASCENT. IS APPARENT DURING COVER, THE RH THE OF

o£ pad one-third on the east feet. of middle to 1200 site from ignition camera Remote tracking at is located vehicle perimeter launch Camera FPS 96 FE 35mm E-53

OK Focus F. O.

OK OK R Exposure

ITEM E-52 FOR COMMENTS SEE Comments:

pad of the east one-third feet. o upper o 1200 0 site t t οĘ from ignition camera tracking at Remote is located vehicle perimeter launch vel Camera 96 FPS 35mm E-54

0 8 8 Focus F. O.

OK Exposure:

OF STINGER FALLS EARLY APPARENT BODY FLAP MOTION. ONCE REGAINED, TRACKING START-UP. ANOMALIES DURING LOV. IS VISIBLE. SSME OMS POD SOON LOST. THROUGH VEHICLE "TWANG" IS APPARENT DURING ON N RH IS GOOD AFTER LIFTOFF, BUT IS SOBSCURED BY PLUME AND NO DETAIL CCS PAPER COVER FROM THE PLUME IN FRAME 103-00. NO COVERS REMAIN ATTACHED VAPORIZES. COVER DOME AFT COVERS EI AN RCS THE SSME FRCS PAPER NO Comments: ASCENT. DENSATE THROUGH VIEW IS VEHICLE

the NW pad one-third o of lower n to 1200 9 camera site vehicle from ignition Remote tracking at is located perimeter. launch veh Camera FPS 96 FE 35mm E-57

었 Focus TRACKING IS ERRATIC

O<sub>K</sub> F. O. V.: Exposure:

FROM FROST/VAPORS VEHICLE SSME IGNITION. CONDENSATE STIFFENER RINGS VAPORIZES FROM TILE FALLS FALL FITTING AND COVER WHITE DOME THE EB-8 RCS PAPER OF AFT FRAGMENT 田田 AT ET AFT DOME AND WATER ON THE SRB FROM OF. FROM VENT LINES ISES. ICE FALLS NUMEROUS PIECES EARLY ASCENT. A FALLS VEHICLE DURING EARLY ASCENT. CONDENSATE THE FSS CRYO VEHICLE RISES. TOWER. Comments: FALL FROM CLEARS THE

ELEVON UPPER SURFACE JUST BEFORE THE COMPLETION JVER. TRACKING IS LOST AFTER ROLL MANEUVER AND IS ROLL MANEUVER. OUTBOARD NOT REGAINED. THE RH THE

one-third of pad the NW feet. 0 center 1200 9 site t 0 οĘ perimeter. Remote tracking claunch vehicle from ignition t camera at is located a er. Remote Camera 96 FPS 35mm E-58

Focus F. O.

TRACKING IS ERRATIC ; > o.

OK K Exposure:

ITEM E-57 COMMENTS FOR SEE Comments: the NW pad one-third feet. e on of upper of to 1200 site ignition is located at camera tracking from Remote vehicle perimeter. launch veh Camera 96 FPS 35mm

OK K .. .. > Focus o بر ابر

TRACKING EXCEPT FOR LOSS OF OK, OK

Exposure:

START-UP. CARRIER ASSEMBLY THROUGH SSME INTACT DURING ET GH2 UMBILICAL 

camera Camera is located on north pad perimeter at site 1 and views the entire launch vehicle, level. zero and MLP 96 FPS 35mm E-60

O K Focus

0 7 8 9 F. O. v. Exposure:

HEADING NORTH AND PASSES EAST OF THE WATER TOWER (FRAME 41-00).

THIS BIRD WAS NOT NEAR THE VEHICLE. RETRACTION AND LATCHBACK OF

THE GH2 VENT ARM APPEARS NORMAL FROM THIS DISTANCE. CONDENSATE ON

THE ET AFT DOME AND WATER FROM THE SRB STIFFFENER RINGS VAPORIZES.

ANOTHER BIRD IS VISIBLE HEADING EAST AS THE VEHICLE CLEARS THE THE FRAME OF SIDE TOWER. NO TPS ANOMALIES ARE VISIBLE THROUGH LOV. ON THE LEFT FIRST VISIBLE IS A BIRD Comments:

pad and east launch vehicle, FSS, the o 0 site camera the at and views located perimeter MLP. i s Camera 96 FPS E-6135mm

O K S, ; > Focus 0

OK Exposure:

SEVERAL PAR-PARTICLES FALL FROM AND NORTH UPWARDS/NORTH AT AS THE VEHICLE ET/ORBITER UMBILICALS. CONDENSATE ON THE ET AFT DOME IR FROM THE SRB STIFFENER RINGS VAPORIZES. AS THE VEHIRS THE TOWER, A BIRD FLIES SOUTHEAST AWAY FROM THE PAD (S HEADED IGNITION APPEARS NORMAL. A DILL.
"THICLE "TWANG" MOTION IS NORMAL.
"THICLE "TWANG" HEADED SOUTHEAST. ICE/FROST SRB EXHAUST HOLE
AME 64-00). ICE/ (FRAME OF THE TO T-0. VE SEEN IN E-60) ANGLE SSME RISE OUT DEGREE JUST PRIOR PASS Comments: AS TICLES CLEARS WATER BIRDS

and FSS, pad perimeter views entire vehicle, SE on the and is located site 3 and camera Camera 6 FP E-62 96 FE 35mm

었 Focus

OK o. v.:

OK Exposure

VAPOR DURING JUST AFTER T-0, APPROXIMATELY 10 PIECES ISE UP OUT OF THE RH SRB EXHAUST HOLE COVERS BY THE CONDENSATE VAPORIZES THAT APPEARED TO PASS ITEM. ICE WATER SSME NOZZLES. RESIDUAL LO2 VAPORIZES PAPER OF. IS NOT VISIBLE IN THIS STIFFENER RINGS LENS. ATMOSPHERIC 6 PIECES OF CAMERA AND TWO PARTICLE 压-40 NORMAL. SRB THE DOME AND WATER IN THE LIFTOFF. THROUGH EARLY APPEARS AFT SKIRT. THROUGH EAR ET/ORBITER UMBILICALS FROM THE RCS STINGERS. THE VERTICAL STABILIZER IN E-40 OF PLUG MATERIAL RISE CLOSE UMBILICAL RETRACTION. IGNITION PROBABLY ALL AROUND SSME SHORILY AFTER ET AFT AFT VERTICAL WAS THROAT VAPORIZES THE NEAR THE PARTICLE ON THE FROM FALL T-0

and camera pad perimeter at came launch vehicle, FSS, SWentire o u located views and ٠<del>.</del> 4 Camera site FPS E-63 96 FE 35mm

OK R 8 ۶ Focus F. O.

OK Exposure:

SSME QUAN-UMBILICAL DISCONNECT. ALL THAN TYPICAL AROUND PRESENT MORE 1-0 SSME IGNITION APPEARS NORMAL. WATER VAPOR ARE DURING SSME lewing ATTER VITTE VATER VITTER VITTER RESIDUAL OF TITIES OF NOZZLES. Comments

LIFT-UMBILICALS AFTER STIFFENER RINGS VAPORIZES SHORTLY ARTICLES FALL FROM THE ET/ORBITER CLEAR. TOWER THROUGH PARTICLES FALL IN PLACE ARE SRB NUMEROUS ICE COVERS THE FROM PAPER WATER FRCS OFF.

and camera FSS, at pad perimeter a launch vehicle, MZ entire go located and views ب ن 9 Camera site MLP. FPS 96 FE 35mm E-64

S K Focus F. O.

OK .. >

OK Exposure:

DELUGE CAUSES WATER RESIDUAL ATMOSPHERIC WATER VAPORIZES GOX VENT ARM RPRESSURE UPSURGE TO GEYSER UPWARD. OF PRESENT AROUND ALL SSME NOZZLES. ISIBLE. SRB IGNITION OVERPRESSURE QUANTITIES T-0 UMBILICAL DISCONNECT. STIFFENER RINGS SUPPRESSION WATER TROUGHS TYPICAL THAN SRB VISIBLE. MORE VAPORIZES DURING AFT DOME AND ARE IS Comments SOUND VAPOR WATER ZI

and the RH camera at #1 and #3 pad perimeter SSME engines S 된 g engine nozzle. located and views Camera is site 3 an OMS FPS E-76 96 FE 35mm

OK K

OK : ⊳ Focus F. O.

OK Exposure:

FROM OCCURS PULLED SEQUENCE APPEARS NORMAL. SSME NOZZLES TRAIL ICE COVERS WHICH UMBILICALS ARE RETRACTION. VAPORS AFT RCS PAPER IGNITION, ALL AND FLIGHT OD AS THE VEHICLE RISES AROUND UMBILICAL #1 I UMBILICALS SSME START-UP CONDENSES AR( ING T-0 UMBILL SSME PARTICLES FROM THE SSME EXHAUST BY ASPIRATION. LEAD PRECEDES ET/ORBITER AND FALL AT SSME IGNITION. SSM ATMOSPHERIC WATER VAPOR CON RESIDUAL LO2 VAPORIZES DURING FROM THE ICE HYDROGEN 13-00. 102 FALL ORBITER Comments: THE IN FRAME TICLES INTO

TH and the camera #2 at SW pad perimeter and #7 engines and views SSME ine nozzle. o G Camera is located engine site 4 OMS 96 FPS 35mm E-77

0 7 8 Focus : F. O. V.: Exposure:

O K

SRB RH ATMOSPHERIC FALL ICE PARTICLES [-0 UMBILICAL. INSTAFOAM, FROM EJECTED IGNITION. SSME NOZZLES. ICE AND THE LH2 T-0 ΟĒ AND THE LH2 QUANTITIES 55-08. TYPICAL COLLEGE ARE WATERIAL ARE #1 SSME PRECEDES WATER VAPOR CONDENSES AROUND ALL FROM BOTH ET/ORBITER UMBILICALS OCCURS IN FRAME 55-08. TYPICAL THROAT PLUG, AND WATER TROUGH M LEAD HYDROGEN Comments:

RETRACTION OF TYPICAL EN SKIRT CLOSED DURING AFT TO HAVE BY SSME ASPIRATION. SRB FALL FROM THE VEHICLE ZH VAPORIZES DURING SPLIT APPEARS THE LO2 TSM DOOR FROM WATER AFT IGNITION. W. ITIES OF RCS PAPER COVERS FA START AND LIFTOFF. LO2 TSM RLY. WATER CONDENSATE FALLS PULLED SPEED BRAKE AS THE VEHICLE RISES. UMBILICALS AND IS 102 AT RESIDUAL HOLE EXHAUST QUANTITIES VAPORIZES. I - 0

from launch vehicle through LOV. flight of tracking early ignition and IFLOT UCS-9 FPS **E-201** 30 FE 70mm

OK : > . . Focus

OK Exposure:

FROM SEPARATION SRB PLUMES STIFFENER FLOW AND OCCUR FALLS SUPERSONIC COMPLETE NUMEROUS FLASHES AND WATER FROM SRB A WHITE PARTICLE ES MAX Q. SRB FALL FROM THE ON THE PAD. LOCAL ROLL MANEUVER IS FOUND ON THE PAD. PASSES MAX THE VEHICLE. MANEUVER. SLAP SHORTLY AFTER LIFTOFF. DOME VEHICLE OF PROPELLANT ROLL ON ET AFT THE TILE/SCREED BABLY THE WHITE TILE/SCREED RCS PAPER COVER FALL AFT OF AS THE JUST BEFORE THE SSME PLUME AFTER CONDENSATE CHUNKS CONDENSATION APPEARS RH WINGTIP Comments: CONI RINGS VAPORIZE IS NOMINAL AND PROBABLY

from vehicle launch through οĘ T tracking of early flight IFLOT and ignition U247L116 FPS E-202 30 FP 70mm

S F DOE SOFT BECOMES EARLY DURING GOOD Focus

IN FLIGHT. EARLY ASCENT. EFFECTS LATER ATMOSPHERIC

OK F. O. V.: Exposure:

OF RCS PAPER COVER THE MANEUVER FROM ROLL FALLS THE NUMEROUS PIECES TILE/SCREED BEFORE JUST OF WHITE ELEVON UPPER SURFACE DURING EARLY ASCENT, VEHICLE ELEVON UPPER PIECE THE 4 OE Comments: COMPLETE. OUTBOARD FALL AFT

from of launch vehicle tracking of launch vehic early flight through LOV UCS-16 IFLOT ignition and FPS E-203 70mm 30

OK K Focus

OK o.

OVEREXPOSED Exposure

CON-STIFFENER JUST OVER A PIECE OF WHITE TILE/ LATER OR FLOW MAX PITCHES SURFACE THE VEHICLE PASSES THROUGH MOF SRB PROPELLANT/INHIBITOR SRB VEHICLE SUPERSONIC THE AND WATER FROM OUTBOARD ELEVON UPPER AS THE PLUME LOCAL SRB PLUM OBSCURE LIFTOFF. COMPLETE. DOME THE CLOUDS BEFORE THE KOLL LANGES AS THE DENSATION BECOMES VISIBLE AS THE ET AFT AFTER 1 OF FALLS OFF RH TRAJECTORY. CONDENSATE ON SHORTLY THE FROM SKIRT INSTAFOAM, VAPORIZE ASCENT FALLS Comments: SCREED

Tracks ET/ORB PAFB IGOR tracking of launch vehicle from acquisition to SRB separation. Tracks ET separation. t t SRB separation **48 FPS** E-204 35mm

Focus : SOFT

F. O. V.: IMAGE INVERTED

Exposure: UNDEREXPOSED

EFFECT IMAGE 361 - 09SOFT THE VEHICLE, FLASH PLUME RECIRCULATION IN FRAME 5 F DETAIL IS NOT DISCERNIBLE DUE SRB SEPARATION OCCURS OF, L AFT 59-02. FALL FRAME PIECES 290-00. NI APPEARS VEHICLE PAPER IN FRAME RCS PLUME Comments: NUMEROUS SSME PI BEGINS

Tracks ET/ORB from vehicle IFLOT tracking of launch acquisition to SRB separation. separation to LOV. SRB Shiloh E-205 48 FPS 35mm

Focus : SOFT

F. O. V.: OK

Exposure: UNDEREXPOSED

ZE. SRB SEPARATION A GLOWING PARTICLE VEHICLE DETAIL HAZE. SEPARATION, CLOUDS, ATMOSPHERIC Comments: ALTHOUGH NOT OBSCURED BY SRB ПO AFTER THE RH SRB PLUME. DUE FOCUS 552-08 BY SOFT FRAME FROM ZH AFFECTED OCCURS

Tracks ET/ORB of launch vehicle separation. LOV. tracking t t to SRB Melbourne Beach ROTI SRB separation from acquisition after 48 FPS E-206 35mm

Focus : SOFT

. O. V.: OK

Exposure: OK

SOFT FOCUS
IS VISIBLE
AME 349-03. FRAME TO EFFECT Z IS NOT DISCERNIBLE DUE SEPARATION OCCURS PLUME RECIRCULATION SEPARATION. SRB SRB ORB AFTER VEHICLE DETAIL IN FRAME 264-00. EFFECTS. ET AND AND ATMOSPHERIC OF. VIEW Comments: STARTING GOOD

Tracks launch SRB separation. to LOV. tracking of separation acquisition to UCS-10 MIGOR SRB after E-207 96 FPS 35mm

ET/ORB

Ø

vehicl

OX A ۶ Focus ó

OK Exposure

BODY SIGNIFICANT THE FROM IN FLIGHT. NO WATER LIFTOFF. AND LY AFTER LIFT VISIBLE EARLY DOME AFT SRB. SHORTLY H THE WAS THE FLAP LATER BY VAPORIZE BODY FLAE NO CONDENSATE OBSCURED RINGS OF THE STIFFENER WAS Comments MOVEMENT

#### EVENT FRAME

TIP RH WING MISSING WHITE  $\mathtt{THE}$ ORBITER FROM TO ORIGINATE OF PIECE SIDE O COVER THE FROM LH AFT RCS PAPER ECT APPEARS IS PROBABLY COVERS OBJECT PAPER OF AND PIECE WHITE 52-00 71-06

OF OF RCS PAPER FALL PIECES THREE

ORBITER OF SIDE FROM LH

#1 PLUME SSME Z FLASH

COVER APPEARS FROM BEHIND ORBITER COVER APPEARS FROM BEHIND ORBITER PAPER RCS PAPER RCS OF. OF PIECE PIECE 

ORBITER APPEAR FROM BEHIND ER FROM THE FRCS COVER FROM FRCS COVER FROM PIECES OF RCS PAPER PIECES OF PAPER COVE TWO TWO

PAPER OF SEVERAL PIECES

RCS THE AFT COVER FROM PAPER OF PIECE ONE

PLUME SSME Z FLASH

PLUME ZH FLASH

#1 PLUME PLUME S SME S SME S SME ZI ZH FLASH FLASH

CONDENSATION SUPERSONIC FLOW LOCAL APPEARANCE OF

#3 PLUME SSME Z FLASH

PLUME Z FLASH

PLUME SSME KH FLASH

SRB PLUME RH OF OUT DROPS PROPELLANT PARTICLE

PLUME FROM FALL PARTICLES NUMEROUS PROPELLANT

PLUME FROM ONE PROPELLANT PARTICLE FALLS

PLUME FROM FALLS PARTICLE FALL OUT PROPELLANT FIVE ONE

PLUME OF PARTICLES

OF PLUME OUT OUT FALLS FALLS PARTICLE PARTICLE ONE

PLUME OF OUT FALL SLAG OF PARTICLES TWO

OF PLUME OUT SEVERAL PARTICLES OF SLAG FALL

SEPARATION APPEARS NOMINAL 3-08

WHICH OF SOME PROPELLANT/SLAG, OF HUNDREDS OF PIECES LARGE QUITE APPEAR

ET/ORB vehicle Tracks launch separation. LOV. tracking of SRB t 0 separation ţο DOAMS acquisition Beach SRB after **48 FPS** E-208 35mm

EFFECTS ATMOSPHERIC TO DUE SOFT Focus

OK څ o , Ju

UNDEREXPOSED Exposure:

ATMOSPHERIC OL D C E 99-04 DISCERNIBLE IN FRAME SEPARATION OCCURS HON SH DETAIL VEHICLE SRB HAZE/CLOUDS. Comments:

of LOV. LFLUT intermediate tracking vehicle from acquisition to launch SHILOH FPS E-209 30 FPS 70mm

**있** Focus

OK ۶ o ri Li

OX X Exposure

PROPELLANT SRB OF SEPARATION. PIECES NOMINAL. SRB PLUMES AFTER HS SEPARATION THE OF. SRB OUT Comments: SLAG FALL FALL

of LOV IFLOT intermediate tracking vehicle from acquisition to UCS-26 launch 30 FPS E-210 70mm

Focus

OK R OK > ° o [x<sub>i</sub>

O K Exposure:

THE ASCENT OF. DUE EARLY IN VISIBLE ARE VEHICLE PLUME THE N THE SSME OBSCURE TH Z CLOUDS FEWER FLASHES RATE. FRAME Comments: SLOWER FR

forward to LOV intermediate tracking of 1 B and ET from acquisition ORB UCS-13 IFLOT οŧ portion 96 FPS E-211 35mm

EFFECTS ATMOSPHERIC OH DOE SOFT Focus

OK .. ⊳ ĮTI O

OK Exposure:

SRB OUTBOARD CONá AT MAX AT FLOW SKIRT RH 103-15. LOCAL SUPERSONIC HE SRB FORWARD ASSEMBLIES THE SRB AFT FROM FROM THE FALLS FRAGMENT FALLS ON THE IN FRAME SLAG TILE VISIBLE SURFACE OF WHITE PARTICLE BECOMES Þ ELEVON UPPER SEPARATION. Comments: DENSATION LARGE

launch vehicl UCS-23 MIGOR tracking of from acquisition to LOV. 64 FPS E-212 35mm

Focus

POOR TRACKING INVERTED, IMAGE IS SLIGHTLY

UNDEREXPOSED Exposure:

SSME FLASHES WHITE THE ASCENT IS OBSCURED BY CLOUDS. A WHI F THE SSME IN FRAME 27-03. TYPICAL SSME VISIBLE AS NOTED IN OTHER TRACKER ITEMS. Comments: MOST OF THE ASCENT IS OBSC TICLE FALLS AFT OF THE SSME IN FRAME ARE AND PARTICLES

ORB of UCS-12 MOTS tracking of forward portion ET from acquisition to LOV. E-213 96 FPS

35mm

Focus

TRACKING DURING INITIAL ASCENT POOR ; > ó

UNDEREXPOSED Exposure:

IN FRAME TILE FRAGMENT OF RCS PAPER FALL FLASHES FOR-SURFACE THE THE AND ZH FROM ROLL MANEUVER. PAST THE VEHICLE 157-03, 162-09, A ELEVON UPPER WATER THE WHITE FALLS ET AFT DOME AND NUMEROUS PIECES LETION OF ROLL M APPEAR IN THE SSME PLUME IN FRAMES 157-03, (LARGEST FLASH). NO APPARENT BODY FLAP MOTION PARTICLE LIKELY OUTBOARD THE PAD AFTER LAUNCH, NUMERO THE VEHICLE AFTER COMPLETION A RH RCS PAPER COVER FALLS IN THE SSME PLUME THE THE SSME PLUME THE THE STATES. WHITE MOST RH ON THE IS ď THE RINGS VAPORIZES. OBJECT OF CONDENSATE OUTBOARD CORNER: 108-13. THIS OF 108-13. AT THE E THE STIFFENER Comments: 179-09, FRAME FOUND

tracking of launch early and vehicle during ignition, liftoff, flight through LOV. IFLOT close-in Beach Road portion of FPS E-217 30 FPS 70mm

OK N Focus

OK

OK N F. O. v.. Exposure:

JUST OF P WHITE FEWER THE SURFACE OF SLOWER PLUME. COMPLETE. NUMEROUS PIECES VEHICLE AND INTO THE PLUME. FROM A PIECE SHORTLY AFTER LAUNCH. A PI E RH OUTBOARD ELEVON UPPER WATER THE OH AFT DOME AND DOE VISIBLE Comments: CONDENSATE ON THE ET AFT DO STIFFENER RINGS VAPORIZE SHORTLY AFTER TILE/SCREED FALLS FROM THE RH OUTBOARD r of the vi Plume are HS ROLL MANEUVER COVERS FALL AFT SSME THE BEFORE THE Z FLASHES

diate tracking of acquisition through LOV IFLOT intermediate vehicle from acquis UCS-26 launch 96 FPS 35mm

SOFT DUE TO ATMOSPHERIC EFFECTS INCONSISTENT TRACKING Focus

٥ 0

OK R Exposure:

SRB STIFFENER THE LOST TILE VAPORIZES. A LARGE WHITE PARTICLE, FERGES AFT OF THE ENT OR A PIECE OF RCS PAPER COVER, APPEARS AFT OF THE LE IN FRAME 21-07. EIGHT PARTICLES OF RCS PAPER COVER FALL OF FLASHES APPEAR IN THE SSME PLUME AFTER ROLL MANEUVER. EARLY ASCENT EXCEPT FOR CONDENSATE ON THE ET AFT DOME AND WATER IN THE CONDENSATE ON THE ET AFT DOME AND WATER IN THE CONDENSATE OF PERHAPS FRAGMENT OR A PIECE OVEHICLE IN FRAME 21-07 AND TWO FLASHES APPEAR

U247L116 IFLOT close-in tracking of forward portion of ORB and ET during ignition, lift and early portion of flight through LOV. 96 FPS 35mm E-220 5mm

Focus F. O.

LATE ASCENT TRACKING DURING POOR ... > .

SLIGHTLY UNDEREXPOSED Exposure:

T-0 UMBILICALS. ATMOSPHERIC WATER VAPOR CONDENSES AROUND NOZZLES. A WHITE PARTICLE FALLS FROM THE RH WING JUST BURNING ICE PARTICLES FALL FROM THE ET/ORBITER RCS PAPER COVER PARTICLES FALL DURING EARLY ASCENT THROUGH ROLL MANEUVER. FLASHES OCCUR IN THE SSME #1 PLUME AT FR 124-02 AND 125-04. THESE FLASHES ARE USUALLY CAUSED BY PIECES OF RCS PAPER COVER BURNING PLUME IN THE AN RCS PAPER COVER ENTERS MANEUVER. NUMEROUS AND WATER IN SSME FLASH APPEARS CONDENSATE ON THE ET AFT DOME NOZZLES. A WHITE PARTICLE IE COMPLETION OF THE ROLL 3 SSME PLUME. A LARGER F 157-08. IN FRAME 163-02, occurs. Comments: CONDENSATE ON STIFFENER RINGS VAPORIZES. AND A RED FLASH THE SSME THE BEFORE FRAME PLUME AND THE

of forward Beach Road IFLOT close-in tracking of for portion of ORB and ET during ignition, leadertion of flight through LOV. 6 FPS E-222 96 FE 35mm

Focus

OK ٠. ۲ ó

VERY UNDEREXPOSED Exposure:

T. A WHITE PARTICLE FALLS FROM THE THE RH OUTBOARD ELEVON UPPER SURFACE Comments: ICE PARTICLES FALL FROM THE ET/ORBITER UMBILICALS. TYPICAL QUANTITY OF RCS BUTCHER PAPER COVERS FALL FROM T VEHICLE DURING EARLY ASCENT. A WHITE PARTICLE FALLS FROM T FORWARD OUTBOARD CORNER OF THE RH OUTBOARD ELEVON UPPER SURFA OBJECT IS MOST LIKELY THIS .00-86 IN FRAME THE PLUME

MORE FLASHES FRAMES 244-FLASHES CLOUD LAYER AT FRAMES AFTER LAUNCH. AND PAD THROUGH A FRAME 114-11 THE AT PASSES FOUND ZH VEHICLE FRAGMENT OCCUR #1 PLUME 270-07. THE TILE Ø AND SSME #

forward f ignition, l through LOV. oŧ tracking during flight IFLOT intermediate  $\mathbf{E}\mathbf{I}$ οĘ and early portion ORB of portion CS-9 and 96 FPS E-223 35mm

liftoff,

BLURRY AND SOFT

OK > Focus F. O. o

O K Exposure:

SIMILAR THE SRB THE ORIGINATE AFTER THE MISSING PIECE OF OCCUR IN TWO PARTICLES 212-00, Q, TWO FALLS (
USUALLY PIECES (
HE AFT SKIRT, S PLUMES OF PROPELLANT/INHIBITOR OR INSTAFOAM FROM THE AFT SKIRT. QUANTITIES OF RCS PAPER COVERS, PARTICLES DROPPING OUT OI PLUMES, AND PIECES OF SLAG.FALLING FROM THE SRB PLUM SEPARATION ARE COMPARABLE TO FILM ITEM E-207. 5 F FLASHES APPEARS 155-01, AND MAY BE NUMEROUS OBJECT THESE PARTICLES ARE AT FRAMES 149-07, 296-04. AFTER MAX A WHITE ELEVON. TIP RH WING FROM THE RH OUTBOARD PLUME DURING ASCENT A 99-12 281-00, AND THE RH SRB PLUME. OF THE RH OUT FRAME N THE AREA 266-03, Comments: FROM TILE FROM SSME ,60

Ø SRB' of splashdown tracks re-entry and deployment, aircraft Castglance parachute 234 E-233,

AIRCRAFT AN TO DUE RUN NOT WERE ITEMS FILM THESE Comments PROBLEM

deployment. skirts forward l parachute the forward record in located cameras are SRB cameras On-board The E-310,302

THESE LAUNCH, PLANNED NIGHT MISSION INSTALLED FOR THIS PREVIOUSLY THE OH NOT DUE WERE Comments: CAMERAS

#### ITEMS VIDEO

M-II 001 OTO B/W

foot 255 FSS the from Orbiter οĘ end aft Views

RESIDUAL MATERIAL ARE BLOWN DISCONNECT SSME PLUME AND CLEARED THE HOLE NORMAL. OWS INTO SSME EXHAUST HO DE THE TSM IS ACTIVATED. T-0 UMBILICAL IS NORMAI THE OD ARE DRAWN AFT INTO TROUGH OF THE TSM AFTER THE VEHICLE HAS WATER GE FLOWS INSIDE T OF LH2 PIECES DELUGE THE LIGHT OF THE FLIGHT SEVERAL WATER CAMERA 1 VAPORS FROM THE RETRACTION TOP ASPIRATION. Comments: UMBILICAL OVER THE

003 OTO

line vent GH2 and Views GUCP

B/W M-II

FOV THE RETRACTION BLOWS ACROSS AND FSS WATER DELUGE DISCONNECT NORMAL. SPRAY FROM THE APPEARS NOMINAL. Comments: SFran IS GUCP

M-II 600 B/W OTO

95 the from area umbilical the FSS. ET/Orbiter LH2 level of Views foot

SPRAY SHOWER LOWER SPRAY/VAPORS FALL VAPOR ICE CONTINUES TO ON N NORMAL. WATER SSME IGNITION CAUSES A BUT VISIBLE. CONDENSATE/WATER
CABLE TRAY SPLICE. ICE CONT ATMOSPHERIC IGNITION ARE ET/ORB UMBILICALS, UMBILICALS' AFTER LIFTOFF. SSME FOV. SSME NOZZLES. PRIOR TO THE CROSSES FROM IS Ħ PURGE VAPORS WATER DELUGE TO FALL DAMAGE ET/SRB VAPORIZES AROUND THE EXIT FROM THE TILE ICE/FROST Comments: THE FSS SURFACE FROM FROM

041 

2 site from camera vehicle tracks and Views

VEHICLE NO T-0, AFTER EXPOSURE PROBLEMS. NORMAL. APPEARS TO SSME IGNITION DISCERNIBLE DUE Comments:

043 OTO

from pad and launch vehicle of side east Views

α, site camera

FOR STACK FLARE HYDROGEN THE AT POINTED WAS CAMERA Comments: LAUNCH.

OTV

9 site camera and tracking view from Launch

STIFFENER RINGS BACKLIT HS WATER FROM VEHICLE ERRATIC. AND DOME HS AFT TRACKING ET NO CONDENSATE VAPORIZES. Comments:

049 OTV

deck from MLP T-0 umbilical Views Orbiter LO2

> M-II B/W

L IS INTO UMBILICAL DRAWN AFT T-0 QD ARE 102 THE FROM THE FLIGHT OF RETRACTION PLUME BY ASPIRATION. DISCONNECT AND VAPORS RESIDUAL Comments: SSME NOMINAL.

050 OTO

deck. T-0 umbilical from MLP Orbiter LH2 Views

B/W

AND FALL FROM THE LH2 T-0 UMBILICAL. DISCONNECT AND RETRACTIVE UMBILICAL IS NOMINAL. RESIDUAL VAPORS FROM THE FLIGHT DRAWN AFT INTO THE SSME PLUME BY ASPIRATION. SHAKE TO PARTICLES ICE/FROST CAUSES AND FALL FROM THE LH2 IGNITION SSME Comments: OF OD ARE LOOSE TION

051 OTO

cluster. Views main engine

B/W M-II

RESIDUAL VAPORS SSME PLUME TEAR COVERS THE PAPER IGNITION INAL. RCS PAPE SSME IGNITION DRAWN INTO IGNITION IS NOMINAL. UMBILICAL ARE AFTER THE PLUME T-0INTO SSME THE LO2 FALL Comments: PIECES FROM

054 OIO

wing and Orbiter RH Views ET/Orbiter LO2 umbilical

B/W M-II

TILE SSME'S ICE/FROST PARTICLES SURFACE UMBILICALS, BUT NO LONGER SILE 'TWANG' IS APPARENT AS THE STREAMONS SHAKE SLIGHTLY AT LIFTOFF. OF SHOWER VISIBLE, VEHICLE 'TWANG' IP. THE RH WING/ELEVONS SHAKE VAPORIZES CAUSES IGNITION THE ET/ORB VAPOR IN THE ATMOSPHERE SSME FROM THROTTLE UP. HS Comments: DAMAGE

and underside SRB Views RH B/W M-II 055 OTO

Orbiter RH

οĘ

SHAKE ATMOSPHERE THE OVER-TO SHA WATER UNDEREXPOSURE OR ET ANOMALIES. PARTICLES UMBILICAL. AT T-0, GEYSERS UPWARD FROM THE WATER VAPOR IN ICE/FROST OL SSME NOZZLES. NO SRB LITTLE DETAIL IS VISIBLE DUE SSME IGNITION CAUSES ICE/FI 102 TROUGHS SUPPRESSION WATER TROUGHS TAVE IN THE FLAME TRENCH. ET/ORB THE FROM VAPORIZES AROUND THE WAVE IN FALL AEC. AND SOUND Comments: PRESSURE CAMERA LOOSE

wing of Orbiter LH and underside Views LH SRB B/W M-II OTV 056

UPWARD FROM CONDEN-SRB OR ET ANOMALIES AT T-0, BLOWN EASTWARD LH ВХ T<sub>0</sub> FROM THE TO UNDEREXPOSURE OF IGNITION. PARTICLES. A WAVE C GEYSERS SLUGE IS EXHAUST UMBILICAL. SSME ALER AT MLP DECK LEVEL TO UNITE DETAIL IS VISIBLE DUE TO UNISSME IGNITION CAUSES ICE/FROST SSME IGNITION CAUSES LH2 UMBILICAL OVERPRESSURE WAVE IN THE FLAME TRENCH. NO DELUGE TROUGHS AFTER FSS SOUND SUPPRESSION WATER FALLS THE FROM DOME SPRAY AFT AND FALL FROM FROM THE ET AF THE VAPORS WATER LITTLE THE AEC. Comments: OF. CAMERA LOOSE WATER SATE

tower. louver from water and NE Views ET nosecone Color M-II OIV 060

AFT DOME LATCHBACK H 되 VENT ARM ROTATION AND FROM THE (CONDENSATE) GH2 OF WATER IGNITION: WALL SSME APPEAR NORMAL. ď DURING Comments: FALLS

SW louver from the FSS Views ET nosecone and Color M-II 061

LIGHT, AST THE WERE PRESENT PLACES PAST LIGHT IN THE UPPER OF THE LOUVER) BLOWN EASTWARD IN FOUR BUT NO ICEBALLS AREA FROM THE FOOTPRINT 1 ON THE -Z SIDE THE LOUVER ARE VERY FOOTPRINT MARKINGS ARE THE LOUVERS, E GRID AND 1 C VAPORS EXITING COATED MISSING NOSECONE FAIRING. GRID FROST WAS MI BELOW THE Comments: RESIDUAL TOPCOAT CORNER.

T-0Orbiter and from the FSS. Views ET/Orbiter umbilical umbilical Color M-II OTV 063

CAMERA LENS. THE CAMERA LIGHT INSIDE THE LH2 TSM IS ACTIVATED AND ILLUMINATES THE T-0 CARRIER PLATE. A SHOWER OF ICE/FROST PARTICLES IS SHAKEN LOOSE FROM THE ET/ORB UMBILICALS BY SSME IGNITION, FALLS PAST THE BODY FLAP, AND IS PULLED INTO THE SSME EXHAUST HOLE BY ASPIRATION. NO TILE DAMAGE IS VISIBLE. LH2 T-0 UMBILICAL RETRACTION IS NOMINAL AND RESIDUAL VAPORS EMANATE FROM PLATE. A SHOWER OF ICE/FROST THE ET/ORB UMBILICATE THE FLIGHT OD. CONDENSATE/SPRAY/VAPORS MOMENTARILY EXIT THE -Y ET/SRB CABLE TRAY SPLICE. CONDENSATE ON THE ET AFT DOME AND WATER FROM THE SRB STIFFENER RINGS VAPORIZE SHORTLY AFTER LIFTOFF. SPRAY FROM THE IGHT INSIDE THE DELUGE WATER CAMERA LENS. TE ILLUMINATES T Comments:

Views overall vehicle from SE direction. Color M-II OTV 070

RETRACTION OF THE LOZ ITY OF RESIDUAL VAPORS ON. ICE FALLS FROM THE N THE ET AFT DOME AND SHORTLY AFTER LIFT-AND A LARGE QUANTITY PLUME BY ASPIRATION. .. STIFFENER RINGS VAPORIZES VERY LITTLE FACILITY DEBRIS WAS VISIBLE. SSME IGNITION APPEARS NORMAL. LINES. NORMAL AND TO THE SSME CRYOGENIC LI SRB ΗS INTO THE T-0 UMBILICAL MLP/FACILITY WATER FROM PULLED Comments:

Views overall vehicle from SW direction. Color M-II **OTV 071** 

HYDROGEN LEAD IS VISIBLE IN SSME #1 NOZZLE PRIOR TO SSME IGNITION APPEARS NORMAL AND ATMOSPHERIC WATER IZES AROUND ALL SSME NOZZLES. RCS PAPER COVERS TEAR FROM THE SHAKEN LOOSE HS ICE AND PIECES FALL INTO THE PLUME. UMBILICALS DURING RETRACTION. SSME VAPORIZES IGNITION. VAPOR

2 site from camera Infrared view 5 (C/S M-II STI B/W

OPERATIONAL FOR THIS LAUNCH SCANNER WAS NOT IR THE Comments:

STI (RSS) Infrared view from RSS roof
B/W M-II

NEAR GRADIENTS SOME CLEARLY VISIBLE. SOME BITER BASE HEATSHIELD THERMAL AND ORBITER SSME THROTTLE UP SEQUENCE IS OH UPWARD START UP SSME #1 DURING IGNITION. HYDROGEN RISES SSME APPEAR NORMAL. Comments: BURNING

TV-2 Views launch from the SLF Color M-II

ANOMALIES. VEHICLE ON N FOR DETAIL. DISTANT TOO HS VIEW Comments:

site from camera launch vehicle entire TV-3 Views Color M-II

9

ANOMALIES VEHICLE ON N TOO DISTANT FOR DETAIL. HS VIEW Comments:

Site. IFLOT vehicle from Beach Road entire Views Color M-II TV-4

OF THE ROLL RH OUTBOARD STIFFENER RINGS ROLL MANEUVER. IMAGE DETAIL S OBSCURE MOST OF THE ASCENT. A FLASH IN THE STHE VEHICLE PASSES THROUGH A THIN CLOUD LAYER. A FLASH IN THE OF MAL. JUST BEFORE THE END (TILE/SCREED FALLS FROM THE LITTLE OVERSHOOT ON THE ROI SOFT FOCUS DETRACT FROM SRB WATER FROM OBSCURE MOST OF A PIECE OF WHITE TILE/ PER SURFACE, VERY LITTL E ON ET AFT DOME AND NORMAL. SHAKE AND APPEARS CAMERA VAPORIZE. CLOUDS OCCURS AS IGNITION ELEVON UPPER CONDENSATE Comments: MANEUVER, PLUME

TV-5 Views launch from VAB roof. Color M-II

AFT OB-FROM T+44 SECONDS. SRB SEPARATION THIS O R SRB PROPELLANT SLAG FALL AND HAZY. SS VISIBLE AT T+44 SECONOR THE LH SRB PLUME, THE PROPELLANT/INHIBITOR DISTANT CONDENSERVED FALLS OUT OF THE LIST OF TO CHUNKS OR SRB PROPELLANT, H THE VEHICLE CONDENSATION BECOMES SECONDS. PIECES THE RH SRB PLUME AT T+134 VIEW OF ONDS, A PART SIMILAR TO SEVERAL EARLY FLOW JECT IS SIMILAF SKIRT INSTAFOAM SECONDS, SUPERSONIC Comments: NOMINAL.

site from camera vehicle of pad. entire launch east TV-7 Views Color M-II

STIFFENER DEBRIS NORMAL. FACILITY IGNITION APPEARS WATER FROM THE SRB VERY LITTLE SSME RINGS VAPORIZE SHORTLY AFTER LIFTOFF. AFT DOME AND OVEREXPOSED. AGE IS O THE ET IMAGE NO VISIBLE. Comments: CONDENSATE

#1 Tower Þ SLF from launch Views Color M-I TV-11

DETAIL DISTANT FOR 100 HS VIEW OVEREXPOSED. IS IMAGE Comments:

vehicle launch Tracks LOV t 0 video. acquisition Beach DOAMS from Cocoa M-II Color TV-13

SRB RING VISIBLE ON 2058 ERRATIC THE VIEW IS HAZY AND CLOUDY. TRACKING IS APPEARS NOMINAL. FAIRLY GOOD DETAIL IS VER SEPARATION INCLUDING THE LONGERON NEAR NO ANOMALIES SRB Comments: SEPARATION ET AFTER SR

and VAB pad οĘ west orbiting from helicopter View M-II Color TV-16

ANOMALIES NO VEHICLE TOO DISTANT FOR DETAIL. HS VIEW Comments:

from Tracks launch vehicle LOV t 0 video. acquisition ITEC Malabar M-II Color

IS TO IS THE RECIRCULATION APPEARS AREA ET, SUCE NO ANOMALIES OGIVE OPTICS. PLUME RECEXCEPT AFT BSM'S 日日 BUT VIDEO FRAME. ETAIL ON THE VISIBLE, SOME DETAIL REVERSED DUE TO NOMINAL BY ONE HS RING, SRB SEPARATION IS ORE FORWARD BSM'S FROM BSM FIRING. 2058 HS THE VIEW NEAR BEFORE Comments: LONGERON APPARENT CHARRED NORMAL FIRE

site from DLTR-3 щ vehicle of Pad launch south directly entire Views M-II Color TV-21

THE BE IGNITION ROLL NO AFTER SCURED BY PLUME. CONDENSATE STIFFENER RINGS VAPORIZES. LITTLE OVERSHOOT. JUST AFTE NOT APPEAR OBSCURED BY CLOUDS. START-UP. BUT DOES SSME FOV DURING OBSCURED BY THE FOV, BI SEPARATION NORMAL. LIFTOFF IS OF 3 AND WATER FROM SRB IS NORMAL WITH VERY BIRDS EXIT CROSSES SRB PROGRAM, A BIRD : TO THE VEHICLE. SEVERAL DOME Comments: MANEUVER CLOSE ROLL

from launch vehicle Tracks LOV. video. acquisition to Patrick IGOR ET-204 Color M-II

SEPARATION APPEARS NOMINAL THOUGH AFT BSM'S APPEAR TAILOFF PIECES AT BSM'S PLUMES THE FORWARD SRB THE ИH BEFORE VISIBLE VIDEO FRAME ARE SLAG SRB ONE PROPELLANT SEPARATION Comments: FIRE

vehicle Tracks launch from acquisition to LOV. ROTI video. Melbourne Beach Color M-II ET-206

SRB LONGERON PLUME RECIRCULATION IS NORMAL. SEPARATION VIEWS OF THE ORB/ET AFT OF SUCH AS THE COVERS FALL ET, OF RCS PAPER THE NO ARE VISIBLE. POST SEE FEATURES VEHICLE DURING EARLY ASCENT. SEPARATION IS NOMINAL. POST SOME PIECES FAIRLY GOOD AND LARGE AND INTERTANK FLANGES, Comments:

from video. Tracks launch vehicle ion to LOV. acquisition UCS-10 MIGOR M-II ET-207 Color

SATION BECOMES VISIBLE NEAR MAX Q AND IS A NORMAL EVENT. JUST BEFORE SRB SEPARATION, SEVERAL PIECES OF SRB PROPELLANT/INHIBITOR /SLAG FALL OUT OF THE PLUME. SRB SEPARATION TO MAY INHIBITOR SEP, HINDREDGE OF SRB PROPELLANT/INHIBITOR SEP, HINDREDGE OF SRB SHORTLY OUT-SOME OF WHICH ARE QUITE LARGE, AFTER LIFTOFF. THE PIECE OF WHITE TILE/SCREED TOST BEFORE BOARD ELEVON UPPER SURFACE FALLS FROM THE VEHICLE JUST BEFORE COMPLETION OF THE ROLL MANEUVER. NUMEROUS PIECES OF RCS PA ARE NOT NEAR NO AND LIFTOFF ARE NORMAL. CONDENSATE ON FROM THE SRB STIFFENER RINGS VAPORIZES SSME PLUME. LOCAL SUPERSONIC NEAR MAX Q AND TO SEVERAL SUPERSONIC A NORMAL AND EXPECTED FOV, BUT  $\mathtt{THE}$ OF PIECES OF SLAG, SRB'S, THIS IS A NOB CROSS BIRDS IGNITION AND SEP, HUNDREDS OF PIE FALL FROM THE SRB'S. SEVERAL VEHICLE. IGNITION AFT DOME AND WATER Comments:

Tracks launch vehicle LOV. from acquisition to video. Cocoa Beach DOAMS M-II ET-208

FIRE CLOUDS TO TO APPEAR DOE POSSIBLY AFT BSM'S ACQUISITION WAS LATE, PARATION IS NORMAL BUT HAZE. SRB SEPARATION IS NOKWAL DU VIDEO FRAMES BEFORE FORWARD BSM'S. Comments:

from vehicle Tracks launch 3 MIGOR video. Tra acquisition to LOV. UCS-23 MIGOR Color M-II ET-212

OUTBOARD ELEVON ROLL MANEUVER. CLOUDS TILE/SCREED FROM RH OF OBSCURED BY COMPLETION SEPARATION IS FALLS FROM VEHICLE JUST BEFORE OF WHITE SRB PIECE OF ASCENT AND Comments:

UCS-7 MOTS video. Tracks launch vehicle from acquisition to LOV. ET-213 Color M-II

AND LIFTOFF OCCURS AT APPROXIMATELY T+16 ON THE VEHICLE DUE TO Comments: SSME IGNITION IS NOMINAL. T-0 GMT 12:35:00. ROLL MANEUVER IS COMPLETE SECONDS. VERY LITTLE DETAIL IS VISIBLE EXPOSURE PROBLEMS.

## 7.2 ON-ORBIT FILM DATA REVIEW

and views umbilical lens the Orbiter LH2 10mm ď with separation ij Camera is and ET 16mm SRB CAM 

STRUT SRB MOVED AWAY. ICE FELL FROM THE LH2 UMBILICAL THE ACPET STRUT THE LH ET/SRB UPPER IRED, BUT THE STRUI DETECTION BUTCHER ON ON THE LH2 UMB1 N N HE VEHICLE. EROSION ON THE AND NORMAL 'POPCORNING' ON OCCURRED. SRB SEPARATION WAS NOMINAL. THE LI SEPARATED CLEANLY WHEN THE ORDNANCE FIRED, RECONTACTED MOMENTARILY AS THE SRB MOVED AWA STRUT FAIRING DURING AND AFTER SEPARATION. OF HYDROGEN FIRE Comments: A PIECE OF STILL ATTACHED TO THE ET/SRB CABE TRAYS ANI

AS THE LH2 UMBILICAL CARRIER PLATES SEPARATED, RESIDUAL HYDROGEN EXITED THE CAVITY BETWEEN THE 17-INCH VALVES. SOME OF THIS HYDROGEN FROZE AND CHUNKS DRIFTED BY THE CAMERA. NUMEROUS SMALL PIECES OF ET TPS WERE MIXED IN WITH THE FROZEN PARTICLES. FOUR LARGE PIECES OF FOAM, CHARACTERIZED BY THE DARKER BROWN RIND ON LARGE PIECES OF FOAM, CHARACTERIZED BY THE DANNEY AP-ONE SIDE, DIVOT SHAPED EDGES, KNIT LINES, AND ISOCHEM LAYER, AP-PEARED FROM BEHIND THE UMBILICAL CABLE TRAY OR FELL AFT INTO THE PEARED FROM BEHIND THE UMBILICAL CABLE TRAY OR FELL AFT INTO THE THESE FOAM PIECES ARE THE DIVOTS FROM THE INTERTANK IN HYDROGEN CONTINUED TO MOVE THROUGH THE FOV, SOME OF TED THE ET AT THE 2058 RING AND BROKE APART. FROZEN HYDROGEN IMPACTED THE ET

WAS NORMAL. THERE WERE NO DIVOTS OR AREAS CHAR-INTACT THERE TANK EXCEPT FOR FIVE LARGE DIVOTS IN THE AREA OF THE BIPODS. WERE NO DIVOTS ON THE INTERTANK-TO-LH2 AND LO2 TANK FLANGES. ET SEPARATION WAS NOMINAL AND THE CONDITION OF THE TAN EXCELLENT. NO ANOMALIES WERE VISIBLE ON THE OGIVE/NOSECONE. RING FROM AERO HEATING WAS NORMAL. THERE WERE NO DIVOTS OR OF THE INTERTANK WAS AREA OF THE BIPODS. THERE METAL SHOWING FOR FIVE LARGE DIVOTS IN THE OF MISSING ABLATOR VISIBLE, NOR WAS BSM BURN SCAR. LIKEWISE, THE ACREAGE EXCEPT

THRUST EFFECTS. FROZEN HYDROGEN FILLED THE ET LH2 UMBILICAL 17-INCH LINE TANK ACREAGE WAS IN GOOD CONDITION WITH THE EXCEPTION OF NORMAL ASCENT HEATING FOAM WAS MISSING FROM THE CABLE TRAY. THE TOP OF THE LH2 FEEDLINE OR LHZ TANK AFT DOME. SHOWED NORW? UMBILICAL WAS DAMAGED AND COVERED WITH FROZEN HYDROGEN. 2 DIVOTS, ONE OF WHICH WAS A REPAIR, IN THE ANOMALIES WERE VISIBLE ON THE LO2 FEEDLINE (VERY LITTLE CHARRING HAD OCCURRED IN TH OCCURRED AND AFT CROSSBEAM, SOME STRUTS, THE LH2

Camera is in the Orbiter LH2 umbilical and views and ET separation with a 5mm lens SRB and ET UMB CAM 16mm

CABLE FIRE DETECTION BUTCHER PAPER WAS FOAM OUTBOARD OF SMALL FOAM PARTICLES UMBILICAL ON THE OUT NO A PIECE TPS N O BARRIER PAINT O CABLE TRAY. OF THE LH2 SIDE OF THE THE AIR AND SMAI ET UMBILICAL IN THE FIRE RIPPLED IN 1 OUTGASSING HYDROGEN OUTBOARD OF F BUBBLES/BLISTERS THE OF THE UMBILICAL TANK AFT DOME WAS THE PIECE STILL ATTACHED TO WAS MISSING FROM ď Comments: TRAY. SIDE

PIECE OF FOAM FELL CAMERA, AND BROKE THE LH ET/SRB UPPER RECON-OF LATER OUT ICE FELL HALVES THE VEHICLE SOMEWHERE ABOVE THE SRB SEPARATION WAS NOMINAL. LARGE STRUT MOVED AWAY. STRUT FAIRING DURING AND AFTER SEPARATION. ď THOUGH THE RECIRCULATION. CLE SOMEWHERE TO PIECES. SRB SEPARATION SEPARATED CLEANLY, THOUG MOMENTARILY AS THE SRB VEHICLE THE PLUME THE SEPARATED STRUCK TACTED CAUGHT STRUT AFT, INTO

BARRIER PAINT ON THE SIDE OF THE UMBILICAL. THE 17-INCH LINE/VALVE WAS FILLED WITH FROZEN HYDROGEN. THE TOP OF THE UMBILICAL WAS DAMAGED AND COVERED WITH FROZEN HYDROGEN. TWO LARGE LONGITUDINAL STREAKS ON THE LH2 TANK ACREAGE WERE PRESENT BEFORE LAUNCH AND OCCURRED DURING MANUFACTURING. THE FIVE RADIAL BANDS WERE CAUSED BY ABORTS DURING THE TPS SPRAYING OPERATION. ALTHOUGH THE LO2 TANK WAS CHARRED FROM ASCENT AERO HEATING, NO ANOMALIES THE FIRE THE AWAY FROM SIDE OF THE VISIBLE IN T AY WAS APPARENT AS THE UMBILICAL SEPARATION. MOVEMENT OF THE ET AW PIECE OF FOAM MISSING FROM THE FORWARD OUTBOARD BILICAL CABLE TRAY WAS APPARENT AS THE UMBILI BUBBLES/BLISTERS WERE REACTIVATED FOR ET S
ORBITER WAS NORMET NORMAL.

and views Camera is in the Orbiter LO2 umbilical 35mm ET separation CAM 

GOOD CONDITION WITH THE EXCEPTION TOP OF THE UMBILI-NO ANOMALIES ITEM. FILM OF TES PEELED BACK ON TOP OF THE IN THE 17-INCH LINE/VALVE. NO AN FEEDLINE. ICE WAS STILL PRESENT ON THIS EXPOSED WERE FRAMES Comments: A TOTAL OF OF THE LOZ ET/ORB UMBILICAL WAS IN OF ICE OR A THIN LAYER OF TPS FCAL. NO ICE WAS VISIBLE IN THE TOPE FEEDLIN THE LOZ FEEDLIN OF THE LOWER FEEDLINE BELLOWS. THE LH2 TANK ACREAGE EXHIBITED TWO DIVOTS, ONE OF WHICH WAS A TPS REPAIR. THE TWO LONGITUDINAL STREAKS WERE PRESENT PRIOR TO LAUNCH RADIAL OTHER HAD BEEN SIMILARLY, THE FIVE SPRAYING OPERATION. THE TPS SURFACE RIND OCCURRED DURING MANUFACTURING. S WERE ABORTS DURING THE TPS WERE ABORTS DURING THE TPS COLORED SPOTS ARE AREAS WHERE LIGHT-COLORED BANDS

CONDITION AND NO GOOD IN AREA WAS THE LO2 TANK ACREAGE ANOMALIES WERE VISIBLE. OVERALL,

AREA. TWO DIVOTS MEASURING 12-14 INCHES IN DIAMETER WERE LOCATED BETWEEN THE BIPODS AND JUST ABOVE THE INTERTANK-TO-LH2 TANK FLANGE. A THIRD DIVOT 14 INCHES IN DIAMETER WAS CENTERED BETWEEN THE BIPOD RAMPS AND EXTENDED INTO THE INTERTANK-TO-LH2 TANK FLANGE. THE LARGEST DIVOT, MEASURING 28 INCHES WIDE, SURROUNDED THE FORWARD PART OF THE LH BIPOD RAMP. STRINGERS WERE VISIBLE IN GE. THE LARGEST DIVOT, MEASURING 28 INCHES WIDE, SURROUNDED FORWARD PART OF THE LH BIPOD RAMP. STRINGERS WERE VISIBLE IN LARGE DIVOTS INDICATING A DEPTH GREATER THAN THE ISOCHEM. A FIFTH DIVOT MEASURING 6 INCHES IN DIAMETER WAS LOCATED GENERATED AGAINST DIVOTS ON THE INTERTANK IN THE BIPOD OUTBOARD OF THE LH BIPOD RAMP AND JUST ABOVE THE INTERTANK-TO-LH2 TANK FLANGE. IFA WAS LINE. THE

### 7.3 LANDING FILM DATA REVIEW

Research at Ames-Dryden Flight Orbiter landing Facility E-1001

ORBITER LIGHTS. THE XENON FIRST THE RUNWAY SEEN. OF. THE OUT BE CANNOT CONTACTS FARS FROM VIEW AS IT MOVES TOUCHDOWN AND ROLLOUT CANNOT WHEEL MEG Comments: DISAPPEARS Comments

Flight Research at Ames-Dryden Orbiter landing Facility E-1002

MLG FROM LH SEEN THE IT MOVES AWAY BEFORE AND ROLLOUT RUNWAY VIEW AS THE FROM TOUCHDOWN CONTACTS DISAPPEARS WHEEL WHEEL MEG ORBITER LIGHTS. NOSE THE Comments: WHEEL: XENON

Ames-Dryden Flight Research at landing Facility Orbiter E-1005

Comments: FILM ITEM DID NOT RUN

Research Ames-Dryden Flight at landing Facility Orbiter E-1006 35mm

TION IS S AS IT ROLLOUT CON LANDING. RH MLG WALLELS CONDENSATION
TO OPRITER DISAPPEARS AS AND TOUCHDOWN WHEEL LEFT MLG OF NOSE VIEW VORTICES. LIGHTS. RUNWAY BEFORE THE BEST WINGTIP THE XENON WAS THE BOTH THIS VISIBLE OF. Z THE OUT Comments: VISIBLE NOT TACTS MOVES ARE

Ames-Dryden Flight Research at landing Facility Orbiter E-1008 35mm

Comments: FILM ITEM NOT RUN

Ames-Dryden Flight Research at landing Facility Orbiter E-1009 16mm

DETAIL CONDITIONS, NO CAMERA POSITION AND NIGHT OF DOE WAS VISIBLE Comments:

Orbiter landing at Ames-Dryden Flight Research Facility **E-1011** 1 6mm

Comments: CONDENSATION IS VISIBLE IN BOTH WINGTIP VORTICES. RH MLG WHEEL CONTACTS THE RUNWAY BEFORE THE LEFT WHEEL. THE ORBITER DISAPPEARS FROM VIEW AS IT MOVES AWAY FROM THE XENON LIGHTS. NOSE WHEEL TOUCHDOWN AND VEHICLE ROLLOUT ARE NOT VISIBLE.

Orbiter landing at Ames-Dryden Flight Research Facility E-1012 16mm

Comments: SAME AS E-1011.

### SRB POST FLIGHT/RETRIEVAL DEBRIS ASSESSMENT 8.0

0800 damage CCAFS Hangar AF on 11 January 1990 from in р**е** debris t t appeared Boosters were inspected for SRB's  $\mathfrak{the}$ general, П at Solid Rocket debris sources 1130 hours. condition. Both

#### RH SOLID ROCKET BOOSTER DEBRIS INSPECTION 8.1

one had missing and the paint 14). in heads Hypalon (Figure four Was locked the bolt frustum The properly areas diameter acreage debond. The slightly only in localized areas MSA adhered to the paint. intact and promi The RH debonds over recovered. Ŋ exhibited covers were not degree open position. slightlyWas but cap οŧ inchheatshield TPS blistered nose The

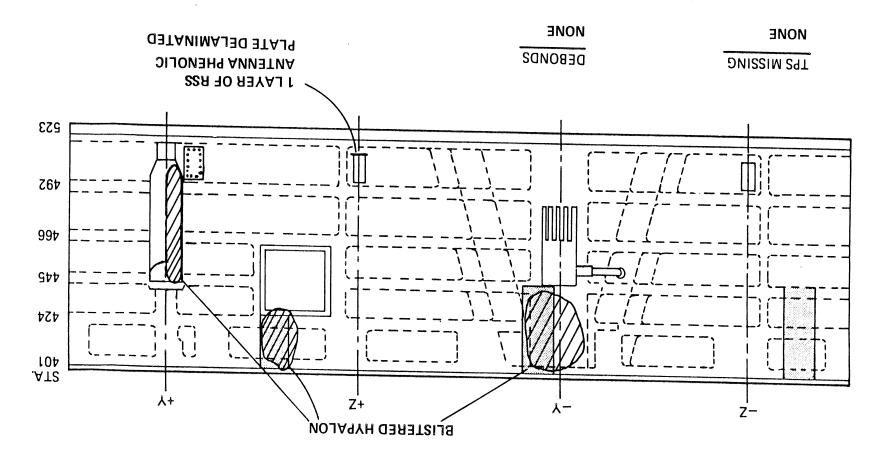
phenolic plate had of the material was forward of fitting inboard TPS. the forward attac... on the exhibited no debonds or missing of MSA adhered to the blistered Hypalon paint flight separated this fligh layer of the pantenna and some interface cable tray. for οĘ the RSS cables accomplished for One layer Separation e RSS cabl the attach fitting. One delaminated on the +Z RSS the The RH Forward Skirt missing (Figure 15). was nominal and closeouts had been the RSS οĘ layers

closeouts and repairs remained intact. The int had a 2-inch diameter bulge at the 185 inches aft of the forward edge. the GEI cork runs was attributed areas bulge at th the forward void undamaged. Known the edge damage to the GEI cork run: from nozzle extension severance. joint had a 2-inch control location 2.5 inches aft of ... damage to the GEI cork : closeouts were joint joint forward field Minor trailing to debris hits degree radial field field

aft two The EPDM adjacent was the adjanta cracked. missing and strut were broken. The strut and a cover bolt οĘ though IEA end cover area Was outboard corner was broken off. A bolt head on t cover was broken off and the RTV interface wa Separation of the aft ET/SRB struts was nominal, the **808** in L bolt head underneath was sooted. The +Y outboard corner was broken off. A bolt he the IEA strut strut the on the upper the upper side of the of aft side side around aft connectors on the ssing near the torn pour missing EPDM. electrical Was

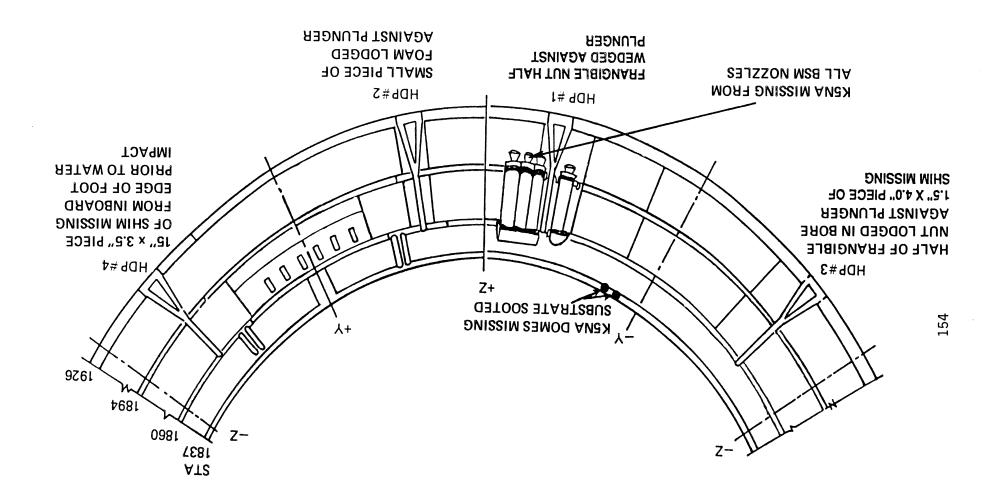
degree location. K5NA was cracked (110-150 degrees) and broken (145 degrees) on the center stiffence. Instafoam was lost from the stiffener rings at splashdown. The K5NA was cracked on the forward web 150

several BSM nozzles. 260 degrees prior to wa missing in u ring delaminated K5NA thermal protective domes were the aft side of the kick ring at 260 four aft igns of heating from all four aft locations. Two K5NA thermal protective signs phenolic material on the kick also missing showed the uncovered areas K5NA was bolt heads on



skirt acreage was generally in good The TVC system appeared to be undamaged. from the aft ring around the aft skirt aft was missing from the aft ring around the exhaust horns, and joint heater umbilical. skirt from ver the aft (Figure 16). over the condition feet, HPU Instafoam

Holddown post #1 plunger was not seated and a frangible nut half was wedged between the plunger and the spherical washer. A small piece of foam was lodged against the plunger in HDP #2 bore. HDP #3 plunger was not seated and half of the frangible nut was jammed in the bore against the plunger. The spherical nut was jammed in the sore against the plunger. The spherical the shim was foot prior to on ..as mi . seated .e of the ... skirt f nut was jammed in the bore against the plunger. washer was displaced. A 1.5"x4" section of shi with substrate sooting. HDP #4 plunger was displaced spherical washer. A 15"x3.5" piece of missing from the inboard edge of HDP #4 aft skirt water impact.



#### SOLID ROCKET BOOSTER DEBRIS INSPECTION TH 8.2

275 ring. localized exhibited were Hypalon paint in degree open position. frustum recovered. The LH frustum s and one 2-inch divot near heatshield the aero οŧ 180 heads and or blistering 17). The BSM locked in the not was over bolt minor There was mindareas (Figure cap and properly nose debonds

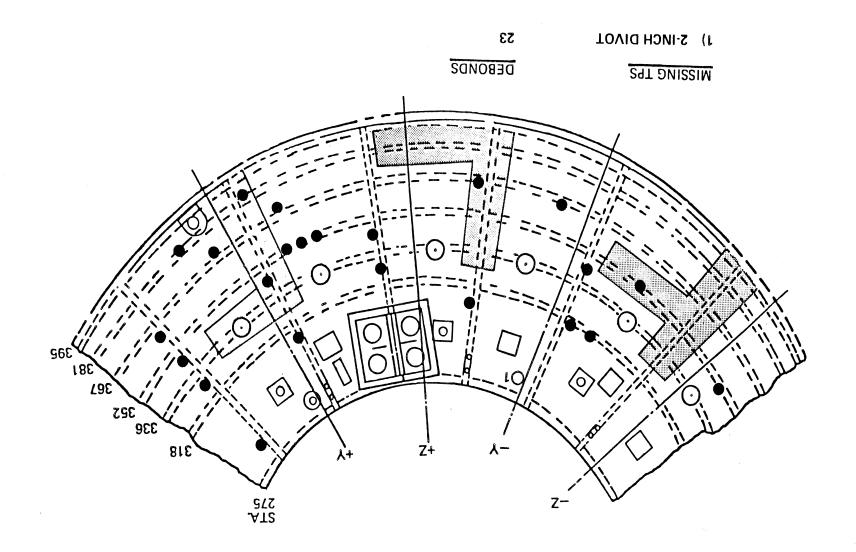
TPS RSS and attach fitting KSNA debonds or missing near material arated cleanly. on the 18). Hypalon paint was slightly blistered ET/SRB thrust post. The phenolic plate on the was delaminated. Some of the phenolic mate was missing. Separation of the forward attacinal and the RSS cables separated clean closeouts had been accomplished properly exhibited no the interface cable tray. Skirt Forward ET/SRB nominal silicone (Figure antenna forward TH

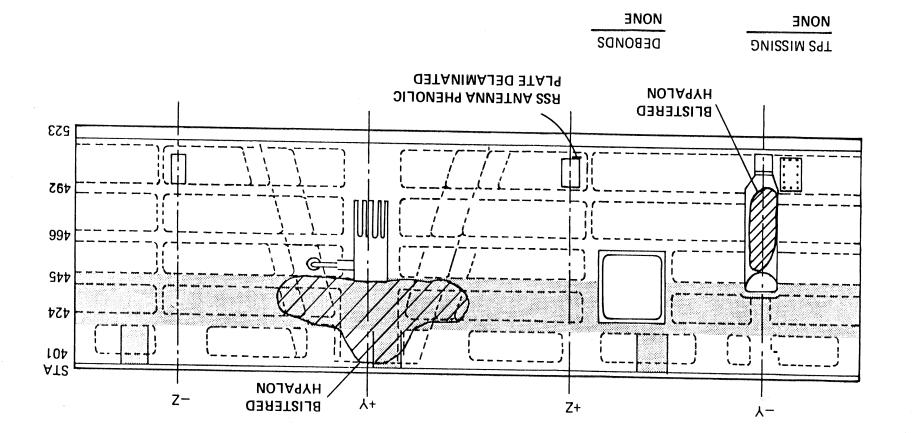
areas Trailing to debris hits void and known intact. attributed were undamaged still were was extension severance. field joint closeouts to the GEI cork runs w closeouts joint nozzle field damage to in the

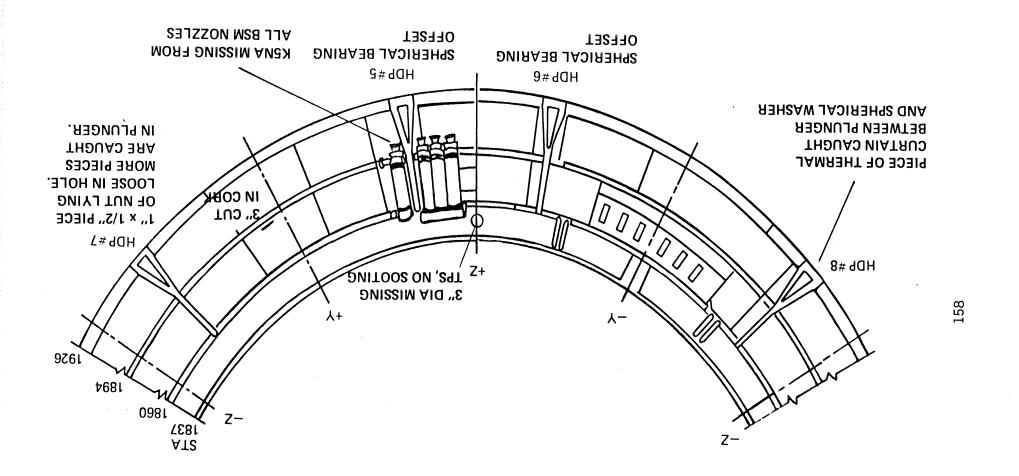
was missing from the ETA ring. Separation of the aft ET/SRB struts was nominal. K5NA on the forward stiffener ring and foam on the center and aft stiffener rings were cracked due to water impact. The aft segment stiffener/stiffener factory joint EPDM IEA joint EPDM 230 degrees the Hypalon deep) Some aft ire seal was debonded on the leading edge at 230 clong by 1" deep) and 280 degrees (3" long by 1.25" intact, but the impact. is on the IEA covers were intact, ted some blistering. PDL pours locations came out prior to water impact. The aft segment sti moisture seal was debonded (3.5" long http://www.debonded exhibited some closeouts paint exhibi bracket bolt was missing

loose ring delaminated in several aft came all four domes rmal protective missing from a Some of the K5NA thermal on the kick Was K5NA phenolic material after water impact. 19). (Figure locations. nozzles The

The HDP #5 and #6 plungers were seated, but the spherical washers were offset. The HDP #7 plunger was not seated and the spherical washer was displaced. Debris chunks were jammed against the plunger and one loose piece of debris (1"x1/2"x1/4") lay in the bore. A piece of thermal curtain was caught between the HDP #8 seated plunger and the spherical washer. This probably occurred during water impact, but the plunger would not have been latched.







# 3.3 RECOVERED SRB DISASSEMBLY FINDINGS

hardware. ou disclosed the USBI 9 set motors booster rocket damage was minimal. STS-32R solid the the οĘ with impact Assessment problems Water

improved apply sealant on The dome peen significantly by the design change to apply seseparation bolt cover and around the flight door. not of the water intrusion. skirts has forward the most likely source the into intrusion

of long standing was identified at and determine against tach structure is stepped and does not fit flat against mpliance ring. USBI will perform an evaluation and determing change. The compliance ring helicoils backed Thiokol will investigate farther than on previous flights. A possible design deficiency compliance

and could indicate the development of a hot gas path. this problem has occurred previously, it could not be covers strut and RH upper and white ablator on the LH re-entry. pinpointed to Although missing

IEA cover faying surface from sealing properly. This hot gas to pass by and the area underneath to be USBI has prepared an FEC to close out this area a manner similar to the end which previously experienced similar problems. Protruding bolts the RH IEA cover allowed hot in sooted. K5NA

and inch bulge in the RH forward field joint at 185 had absorption bulge cork The The during disassembly. The had expanded from water ment process anomaly. The seal. s a cork treatment process from the substrate moisture had examined that f cork a 0 degrees was suspect section of indicates The

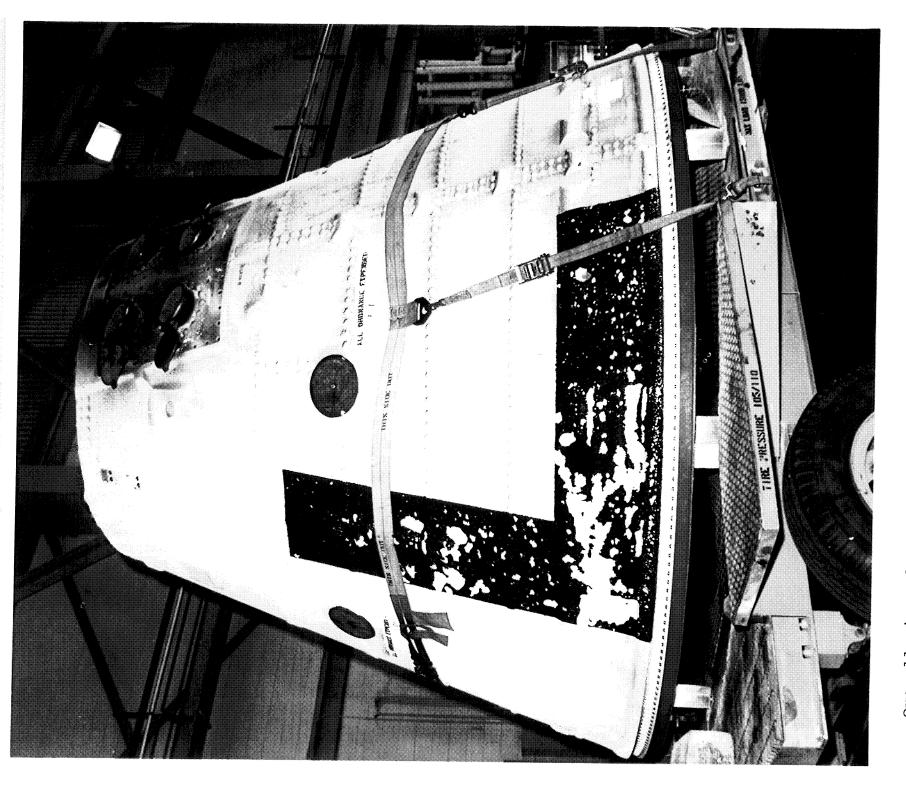
showed the usual, and according to in the putty, but there was no ching too close to the gask-o-seal. the putty approaching too embly of the igniters sexpected, blow holes Disassembly οĘ evidence

A program decision prior to launch had removed the frangible link between the DCS plunger and the holddown stud because of suspected stud hang-up problems. Although there were no stud hang-ups on this flight, this change allowed a considerable USBI but DCS's. hang-ups on this flight, this change allowed a consamount of frangible nut debris to escape the DCS' measured the percentage of potential debris retained, total does not include the frangible nut halves:

	70%		9
#	HDP #6	#	#
%	3%	%	%
#1	P #2 53	#3	#4
H	HDP	H	Ħ

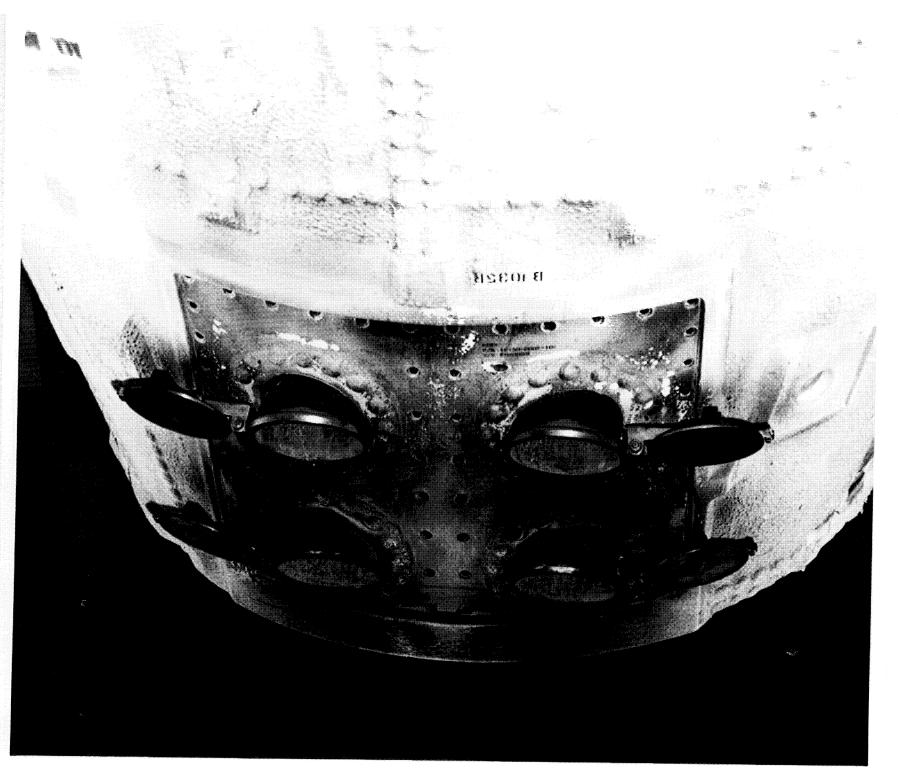
ა დ • and the DCS on this flight to be unacceptable and The quantity of debris lost from considered by the Debris Team tpotential hazard to the vehicle.

Post launch anomalies are listed in Section 11.3.



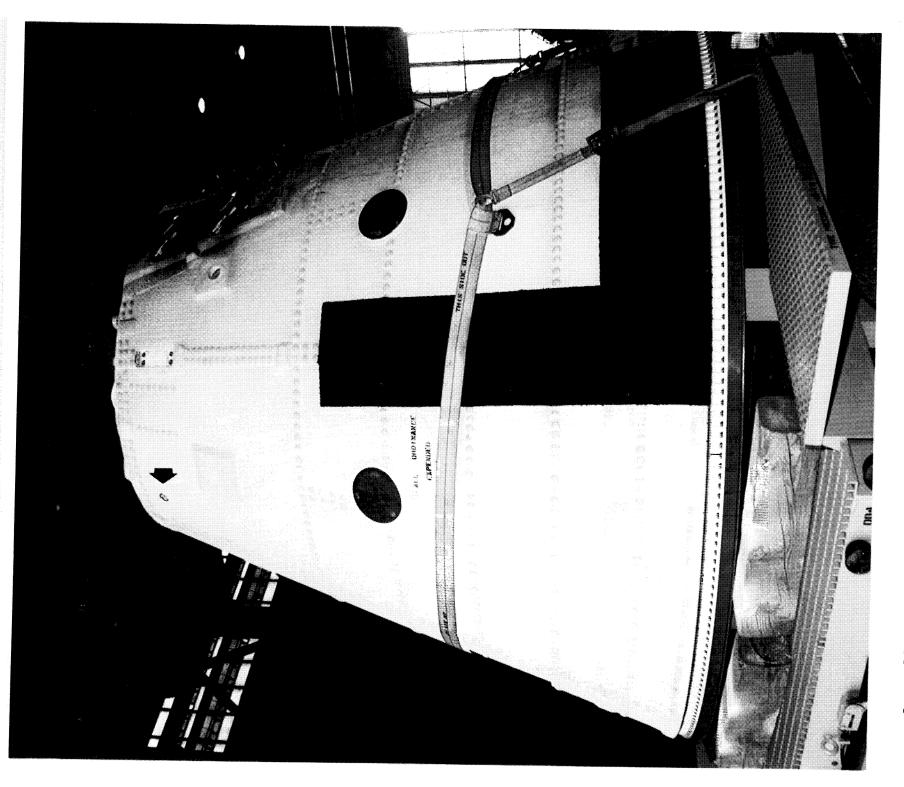
Overall view of RH frustum. Black Hypalon paint in visibility

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				*	



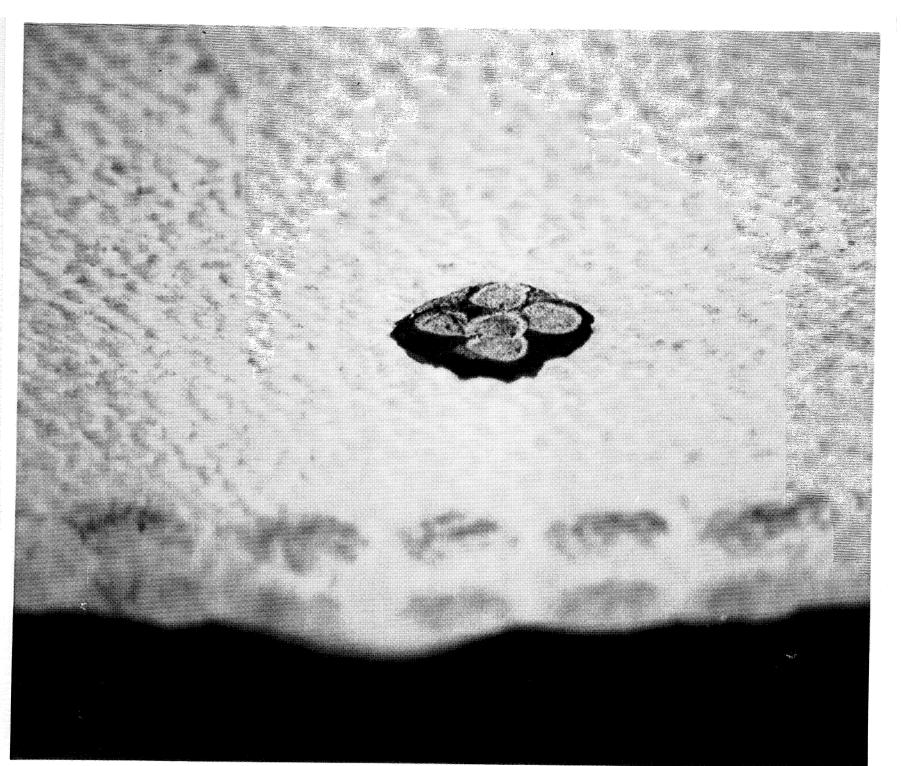
All forward BSM covers were fully opened and properly locked in the 180-degree position 162

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A two inch diameter piece of MSA area near the 275 ring. Overall view of LH frustum. A two inch is missing from an

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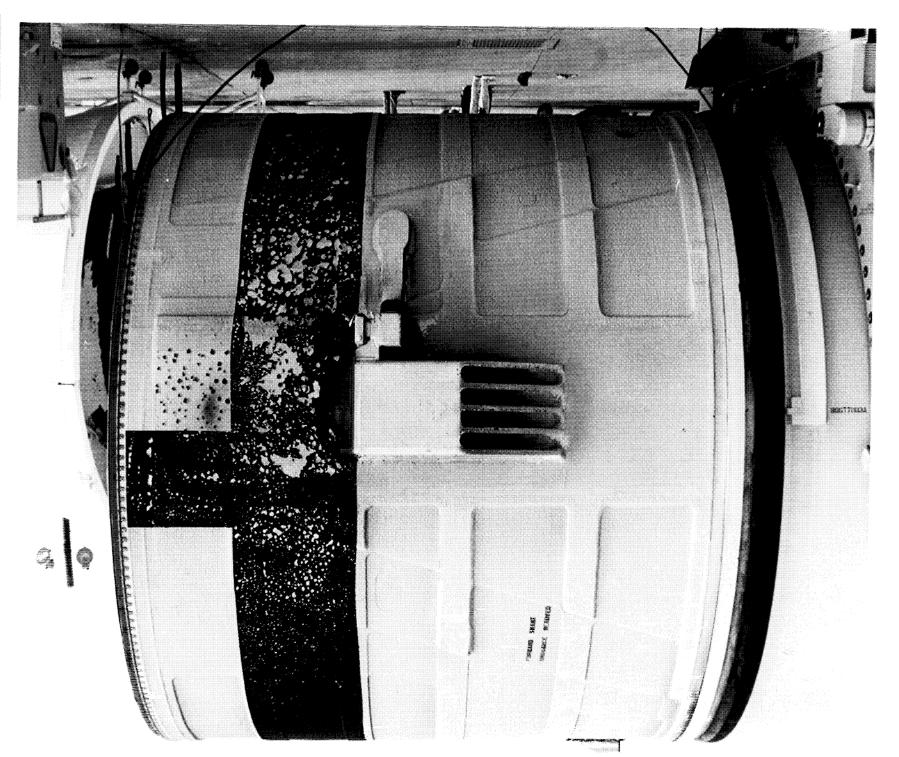


Close-in view of missing MSA near the 275 ring frame

164

ORIGINAL PAGE COLOR PHOTOGRAPH

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ORIGINAL PARE COLOR PHOTOGRAPH ISA adhered to the thrust fitting. Some MSA of the thr LH forward skirt. blisters forward Overall view of Hypalon paint



Close-in view of Hypalon paint blisters with MSA attached

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some material SRB +Z RSS antenna phenolic plate lost from the delaminated layers 167

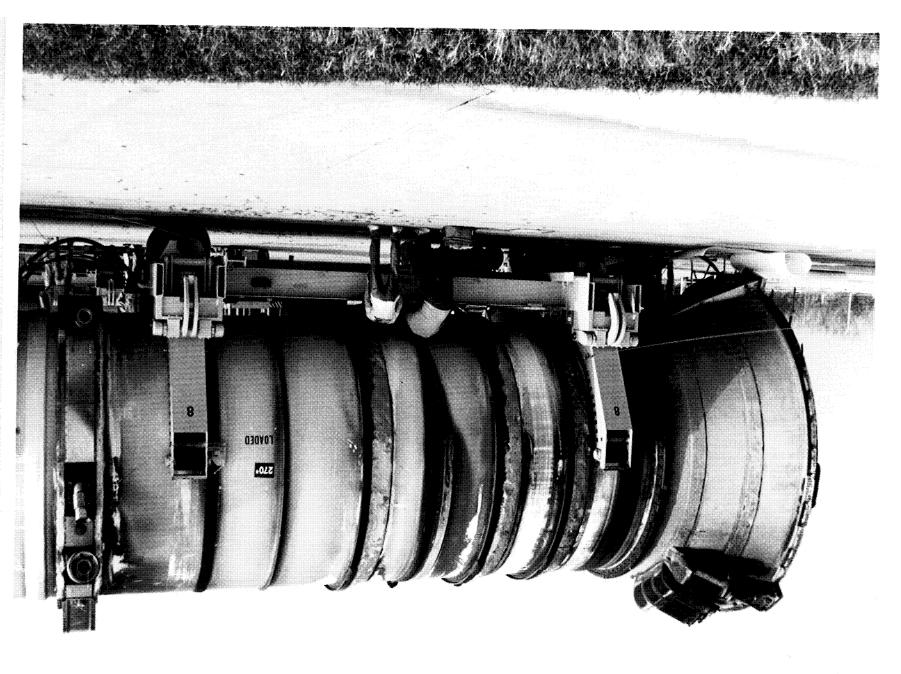
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Typical condition of SRB cases after flight/retrieval

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Overall view of aft booster after flight/retrieval

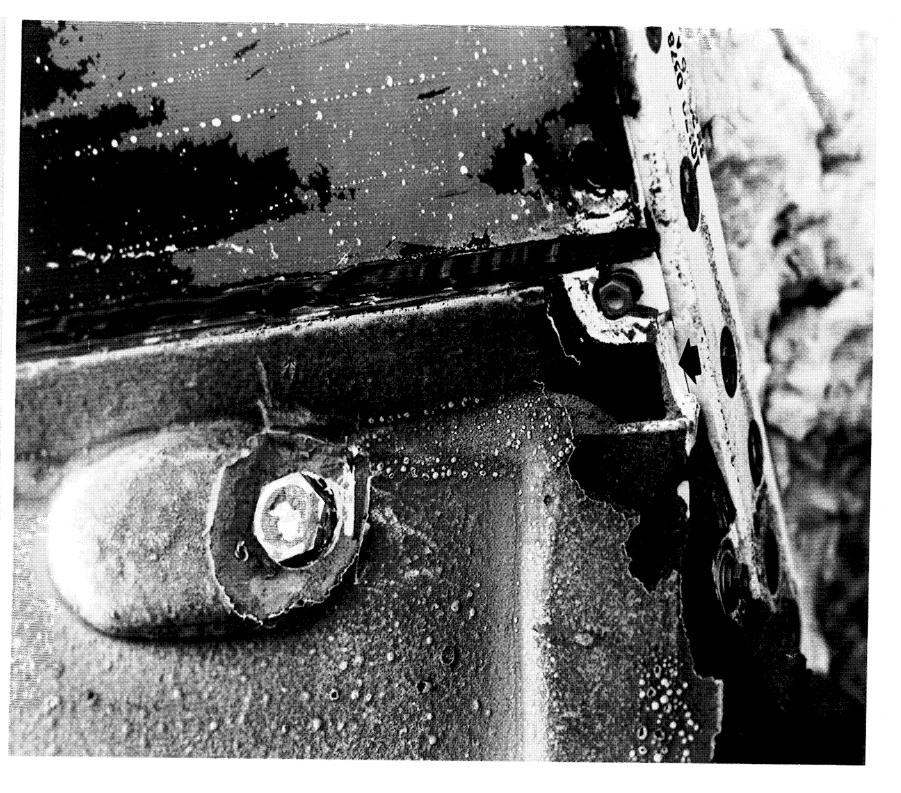
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Missing bolt head and torn/missing EPDM cover at RH upper strut

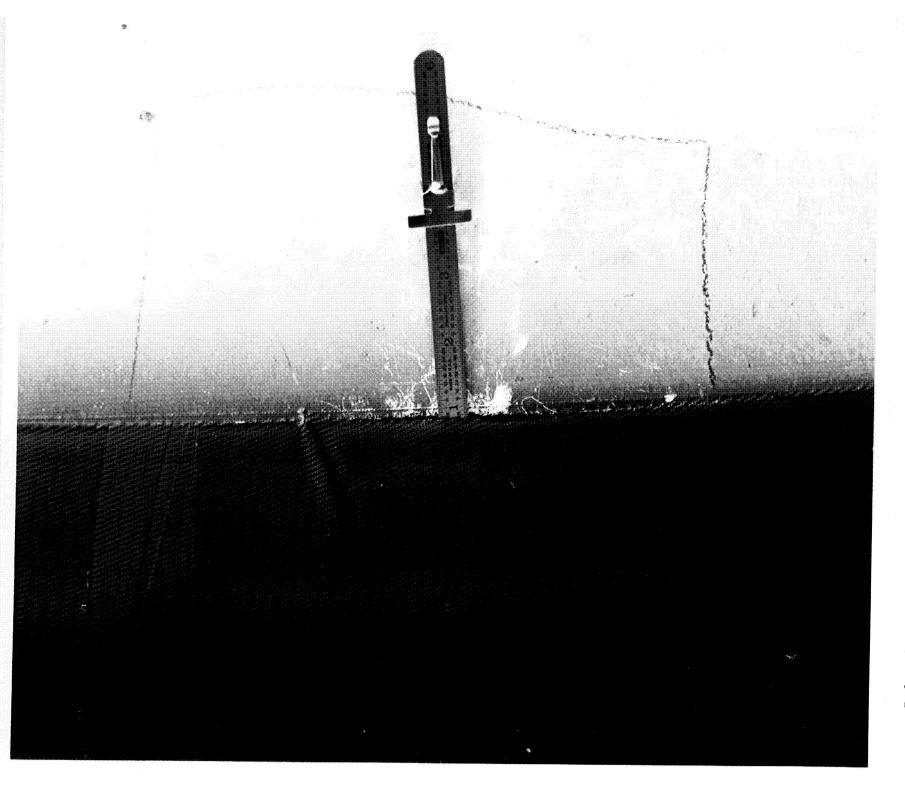
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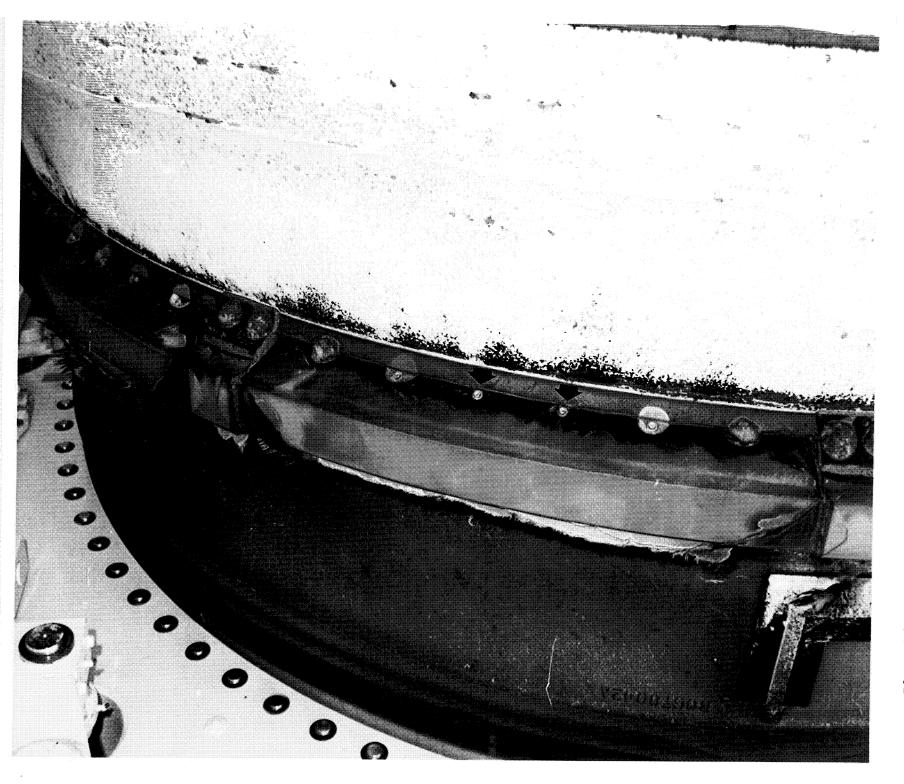
to RH ETA cover ablator and broken/missing corner Missing

	3			*	*		
,							



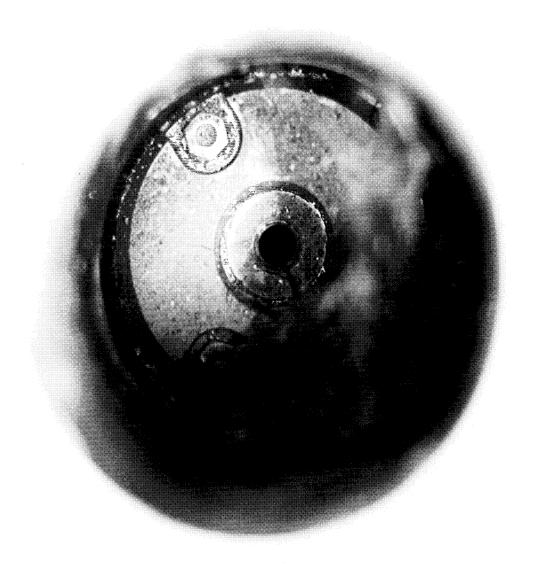
factory joint EPDM Debond on leading edge of LH aft booster moisture seal moisture a

¥ 5	¥	



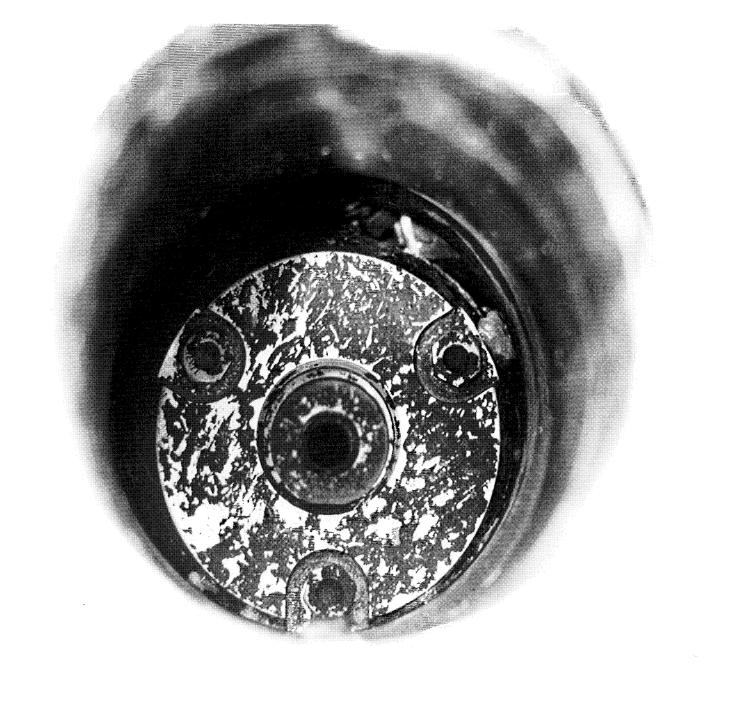
Phenolic delamination on aft kick ring. Note missing bolt (arrows). head K5NA protective domes

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*			*		



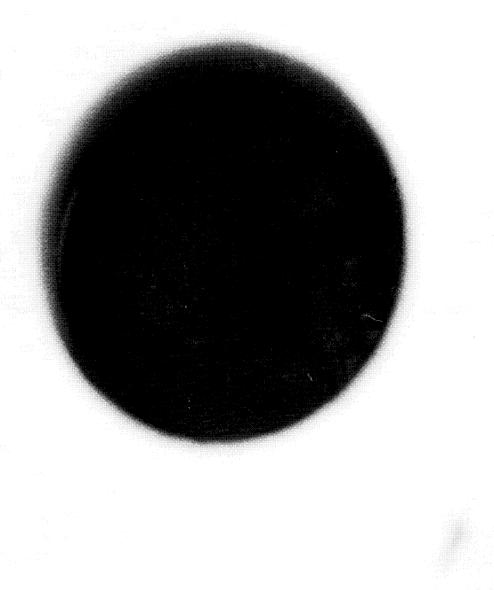
#8 Fiece of SRB aft skirt thermal curtain pinched between HDP

	¥ ¥		*		



Small pieces of ordnance debris and shim material are wedged between HDF #7 and spherical washer 175

		*		



#3 debris Frangible nut pieces have prevented the HDP plunger from seating properly 176

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Half of a frangible nut is wedged against the HDP #1 debris
plunger in the aft skirt stud hole
177

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## ORBITER POST LANDING DEBRIS ASSESSMENT 0.6

a major (EAFB) on Runway identify debris The Orbiter TPS does not include (Columbia) impact damage, and if possible, debris sources. sustained a total of 120 hits, of which dimension of 1-inch or greater. This total does approximately 100 hits on the base heat shield. January detailed Post damage, in conducted

of which 13 previously ET separa-19 previous 30, which had damage .......he total number of hits on the lower of the LH2 considered concentracenterline. damage damage (excluding missions o£ A heavy (50) occurred just aft and inboard s concentration of hits has occurred surface is average. Also, based on the severity of indicated by surface area and depth, this flight is to be better than average. Figures 20-23 show the during hits, lower surface out the vehicle catatistics from of 111 impacts greater. surface had a total ice about d equally about numbers to state configuration Figures the to umbilical average. Fi or STS-32R. these numbers οŧ the dimension of remainder and divided assessment for ), indicates is average. 1 similar , 27R, a is attributed Orbiter lower This of a. of hits approximately 26R, The a major comparison umbilical. sources), missions damage

single, largest, lower surface damage site occurred on the chine and measured  $2" \times 3" \times 1/2"$ . single, largest, The

position on SSME insulation damaged. o'clock average. only slightly da 6 o'clock position #2, and the 7 o'clo SSME nozzle insu the base heat shield tiles was Were the the damage at the sition on SSME t 0 engine closeout blankets o'clock position #3. No damage blankets sustained t t SSME Damage 2-4

I - 0resulted from sleeving material were loose 102 the JH OMS pods leading edges and near detectable damage to adjacent tiles I gap filler pieces of g and LH OMS gap fillers both RH and umbilical. No these

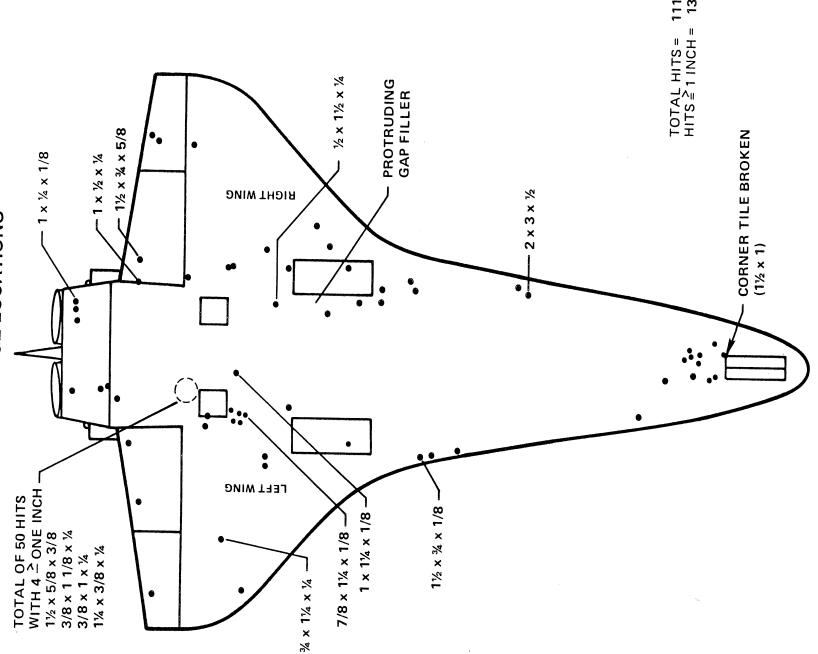
RH wing leading window e streaks were present on the RH win Orbiter window #3 was heavily hazed, streaks. Six typical white streaks were present edge RCC panels. Orbiter window #3 was he was lightly hazed, and window #2 had two

დ დ sites #1-8, selected damage analysis. windows from Samples of deposits/material were taken streaked RCC wing panels, and other shown in Figures 24-25 for laboratory

inspec-forward properly. tion of EO-1 revealed the ordnance device had rotated forward sufficiently to contact both RH and LH bulkhead pyro connector the EO-1 bipod The plungers seated on EO-2 and EO-3, and the EO-1 big bolt piston was flush with the outer mold line. Closer tion of EO-1 revealed the ordnance device had rotated sufficiently to contents.

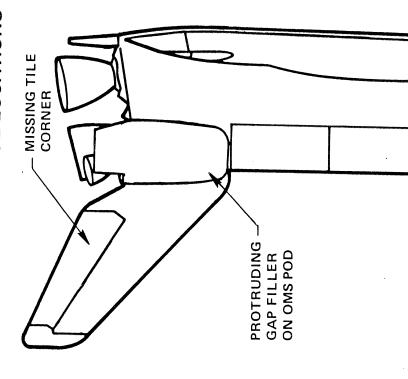
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FIGURE 20. DEBRIS DAMAGE LOCATIONS



EGG/V-088B

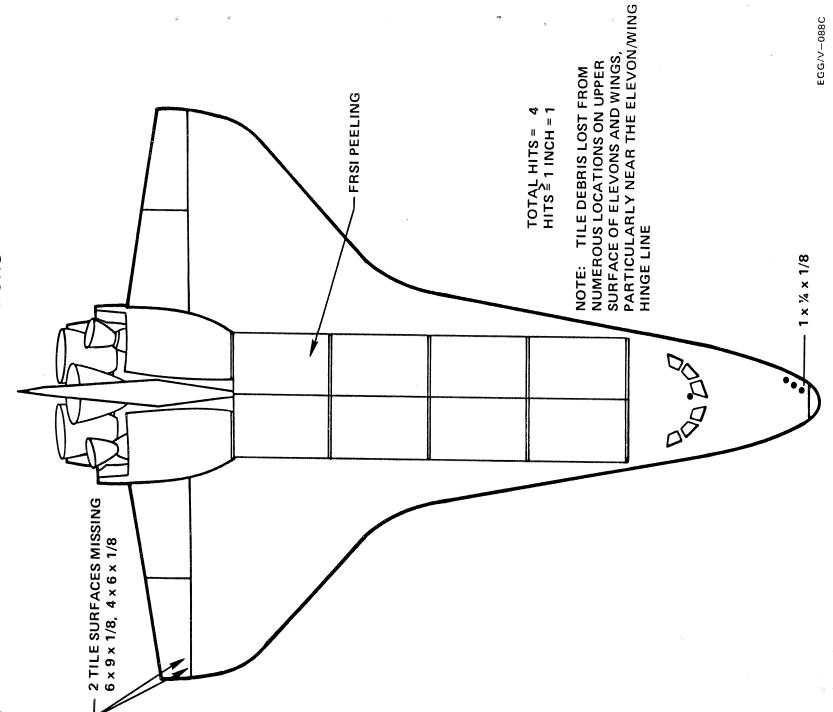
TOTAL HITS = 1 HITS = 1 INCH = 1 EGG/V-088A



TOTAL HITS = 4 HITS = 1 INCH = 0

181

EGG/V-088



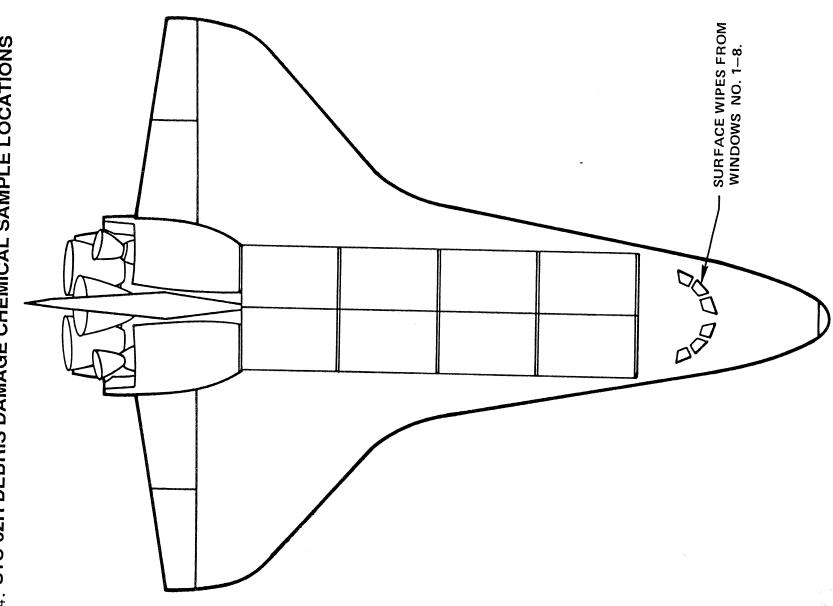
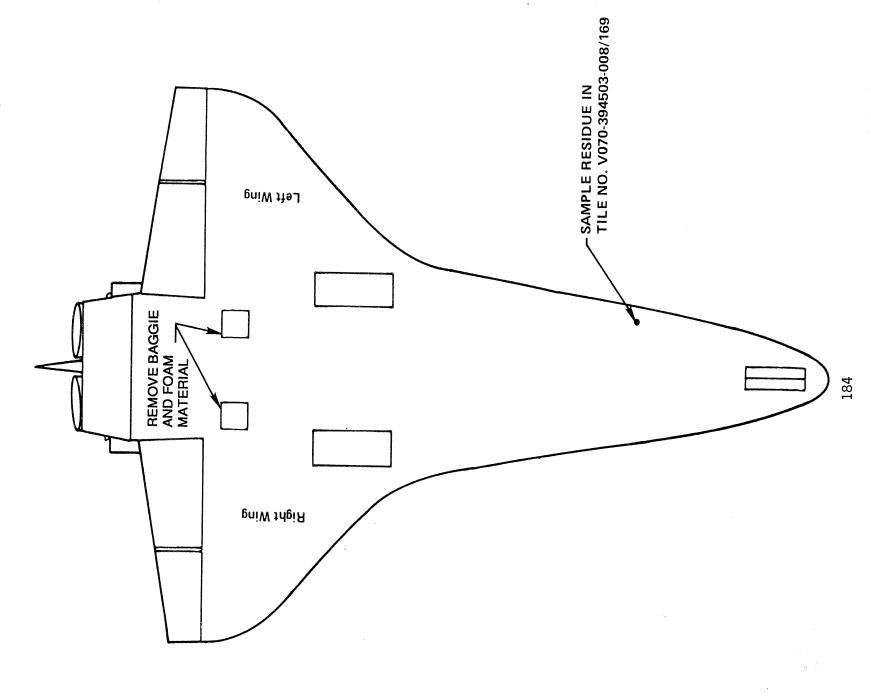


FIGURE 24. STS-32R DEBRIS DAMAGE CHEMICAL SAMPLE LOCATIONS

STS-32R DEBRIS DAMAGE CHEMICAL SAMPLE LOCATIONS FIGURE 25.



in ordnance on STS-34, თ დ broken the which had bent not o scratch marks were backshells bolt, compressive loading. alls, as evidenced by spring housings. The b. The RH Y-Y centering οĘ signs backshells, device spars strans showed

tires, the from to material attributed Was or brakes. damage TPS wheels, No

wing the Twentyand the RH wing RCC panel of record temperature c es F, the RH Orbiter. τo nseq 150 degrees the ambient Was g areas (STI) degrees F, a (Figure 26). an measured after landing with Imager several nosecap RCC 65 degrees F Thermal 72 temperatures of measured Shuttle degrees, the RCC panel #9: #17 measured ( the minutes KSC surface five

because runway inspected and cleaned by Air Force personnel 19, 1990. The general condition of the runvlake bed runways were not inspected becau landing. for them unacceptable and 19, 1 The lake standing water made was 22 18 good. January Runways

performed Was 22 was perror flight hardware of Runway landing. No The post landing walkdown approximately 30 minutes after landing found.

ass for The distribution s, but indicates a constantification of debris sources. The potential identification of debris mission STS-32R will be based on the laboratory to previous flights 27-28). The distribut source surface Orbiter TPS single ice and ď to of lower indicates a shedding ...wnen compared to charts (Figure 27 does not and photographic analysis. number was average comparison c summary, the total Orbiter but was the TPS s on the debris, in the random for debris hits analysis of components, hits sonrces ascent shown In

Section 11.4 listed in Orbiter Post Landing Anomalies are

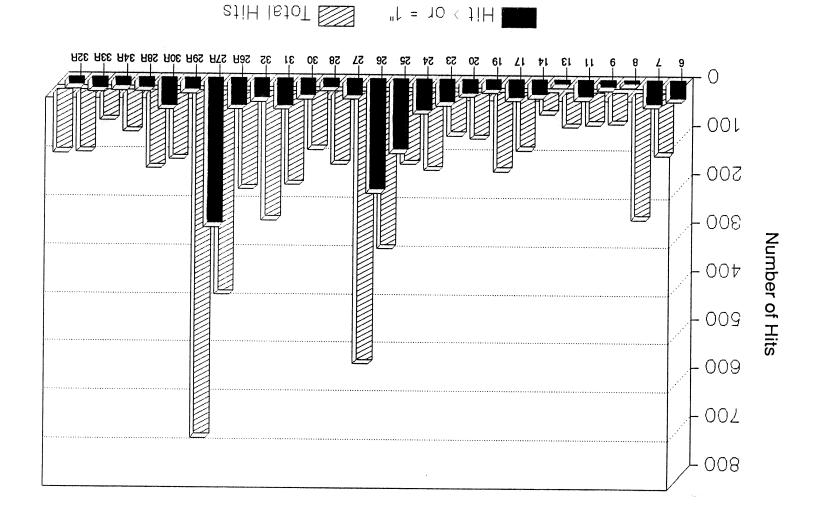
STS-32R DEBRIS DAMAGE ASSESSMENT SUMMARY FIGURE 27.

	Hits > or = $1$ "	Total Hits
Lower Surface Upper Surface Right Side Left Side Right OMS Pod Left OMS Pod	13 0 0 1 0	11 4 0 4 1 0
TOTALS	15	120
	COMPARISON TABLE	
STS-6 STS-7	ଧ <b>ନ</b> ତ ୟ	120 253
8-	7	56
-9 (41	14	58
1 (4	34	63
-13 (41	88	36
-14 (	30	111
STS-17 (41-G)	36	154

()	253	) ц	, rU	63	36	Н	154	σ	81	ഗ	4	Н	ഥ	4	~	α	ഗ	193	7	0	ന	S	16	53	118	120
ဗ္	48	7	14	34	80	30	36	20	28	46	63	4	226	33	1.7	34	55	39	55	298	23	56	20	18	21	15
TS-	STS-7	TS-	TS-9 (41-	TS-1	TS-13 (41-	TS-14 (41-	TS-17 (41-	TS-19 (51-	rs-20 (51-	rs-23 (51-	rs-24 (51-	rs-25 (51-	rs-26 (51-	rs-27 (51-	rs-28 (5	rs-30 (61-	rs-31 (61-	rs-32 (61-	rs-26	rs-27	rs-29	[S-3	rs-28	[S-3	rs-33	rs-3

## COMPARISON TABLE

FIGURE 28.



STS

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Shuttle Thermal Imager infrared views of Orbiter touchdown and rollout. Note tires, RCC nosecap, and APU exhaust near tail.

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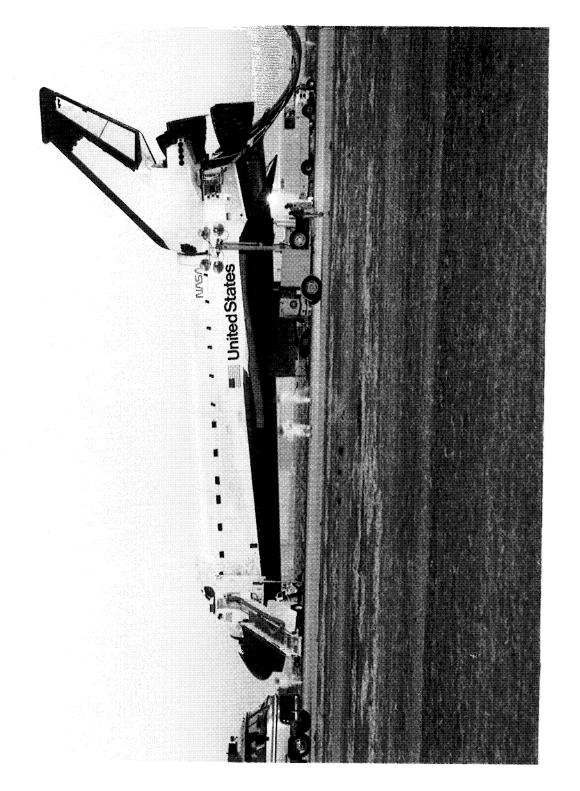
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Colorized STI thermal images show warm areas on RCC nosecap, wing leading edge, and AFU exhaust ports near base of tail.

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Overall view of Orbiter left side after landing



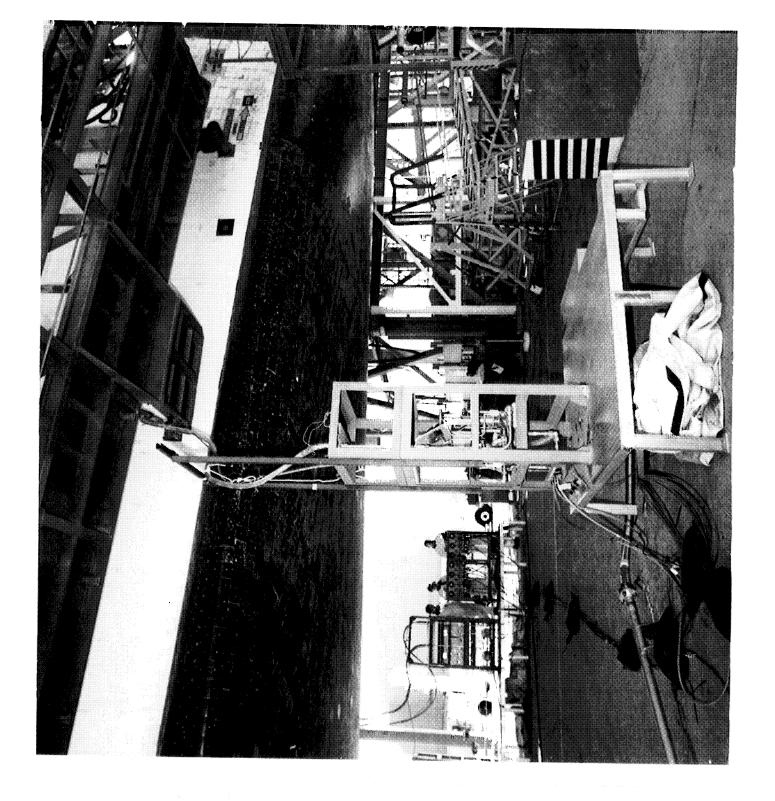
Overall view of Orbiter right side after landing

192

X2			
	* "	į	

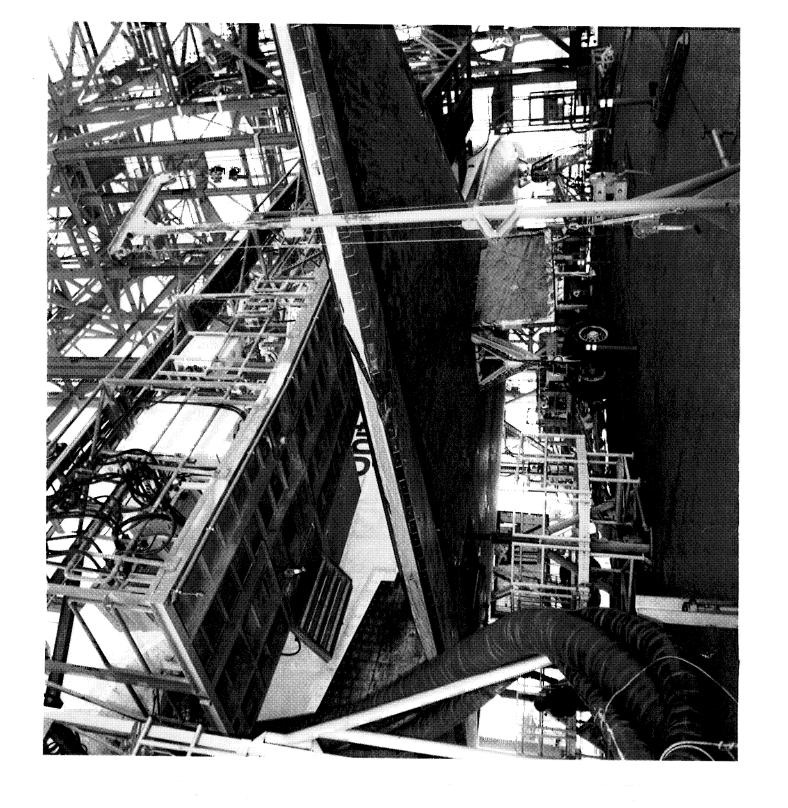
to mid-fuselage from nose lower surface tiles ο£ view Overall

**	*	<b>3</b>	



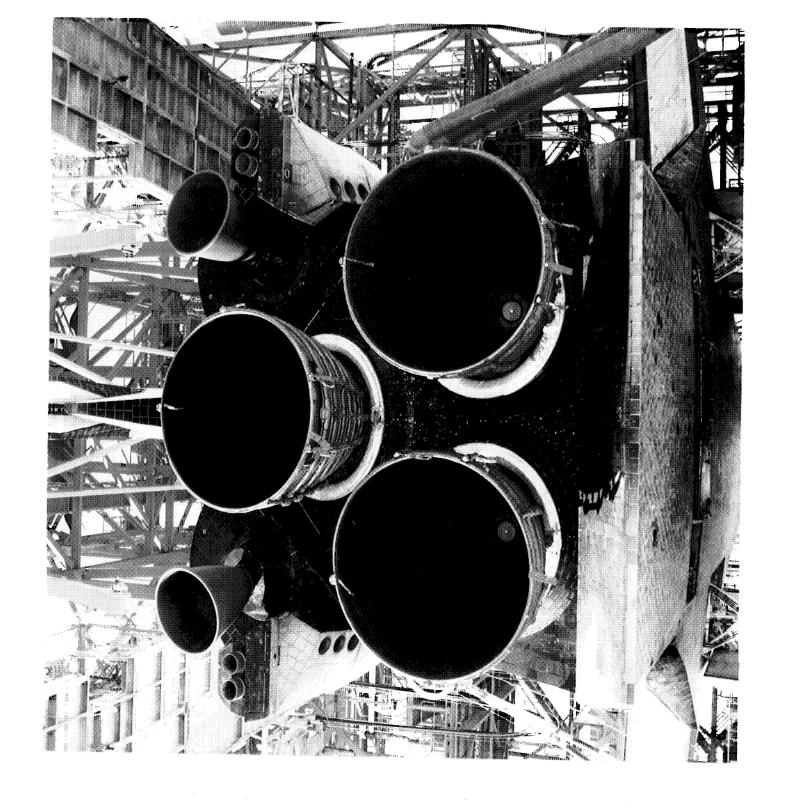
surface tiles near right chine area of lower view Overall

	· ·		*	
• 1				



surface tiles lower of right wing 195 view Overall

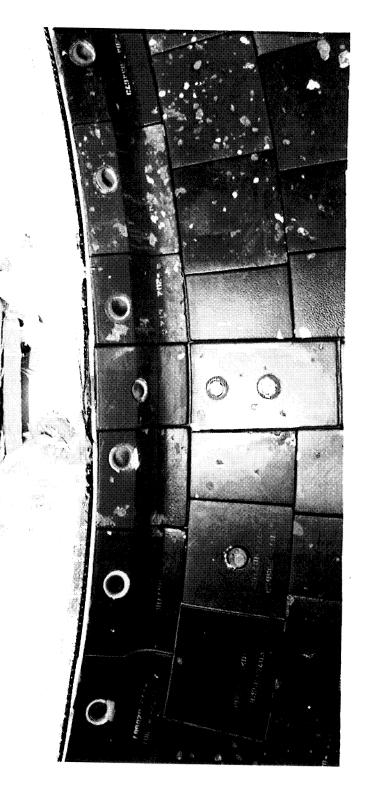
	g &	¥		
			Nac. 1	



Overall view of SSME's and base heat shield. Note thermal blanket damage below SSME #1.

ORIGINAL PAGE

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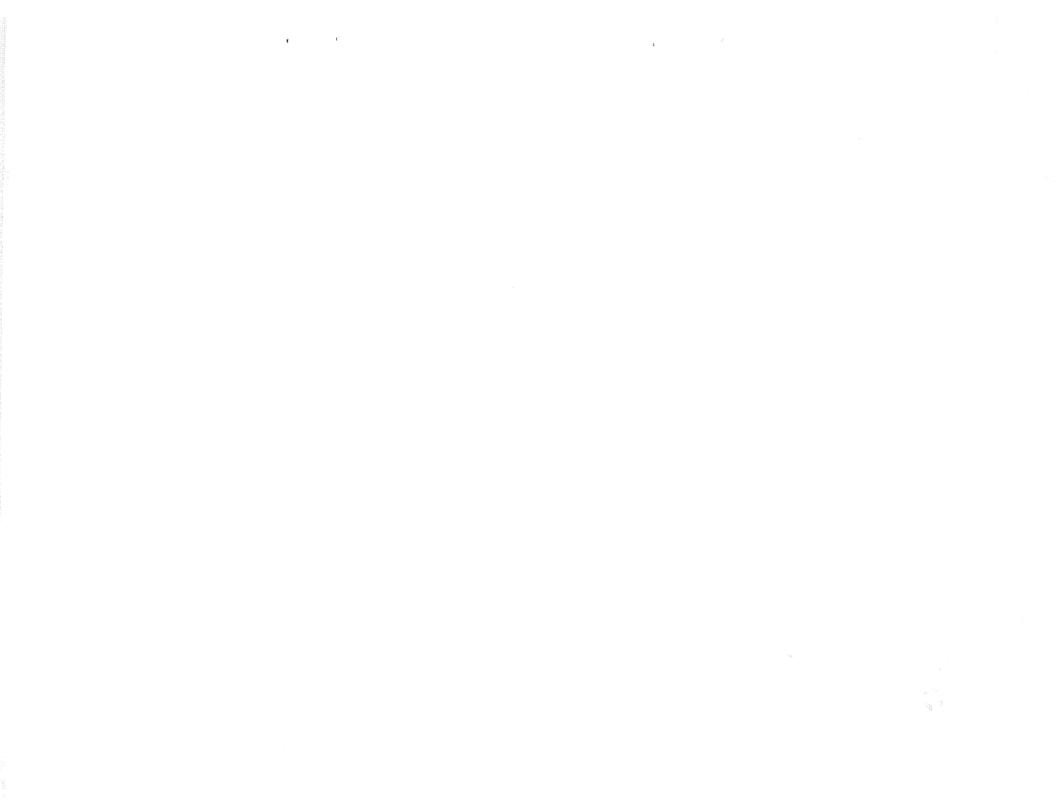
o'clock 9 at damage Close-in view of thermal (beta) blanket position on SSME #1

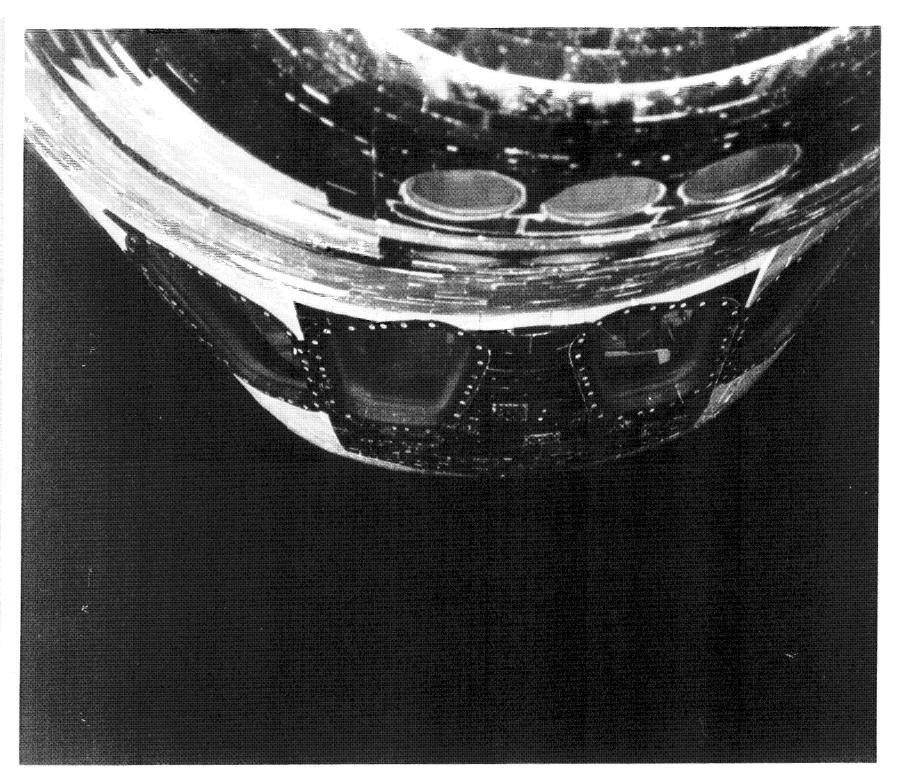
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closeout baggie material still adhere to the LO2 ET/ORB umbilical of Pieces



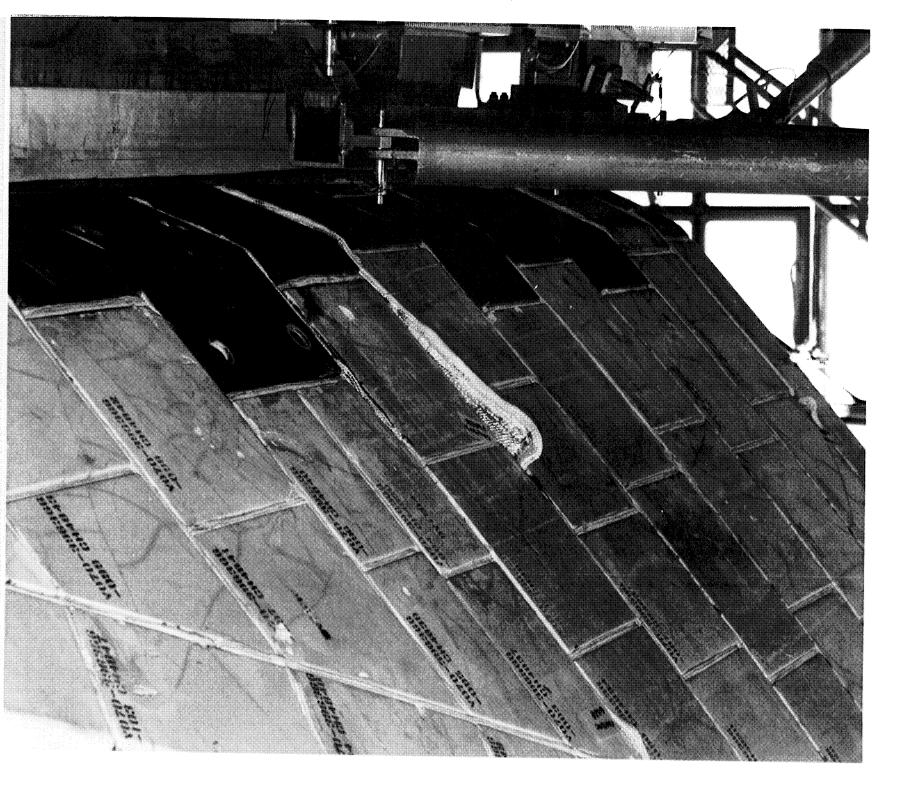
Overall view of LH2 ET/ORB umbilical. Two 16mm cameras with 5mm and 10mm wide angle lenses are located right of the umbilical.





and #4 Hazing is visible on the forward facing windows #3

Ŷ i		<b>3</b>	

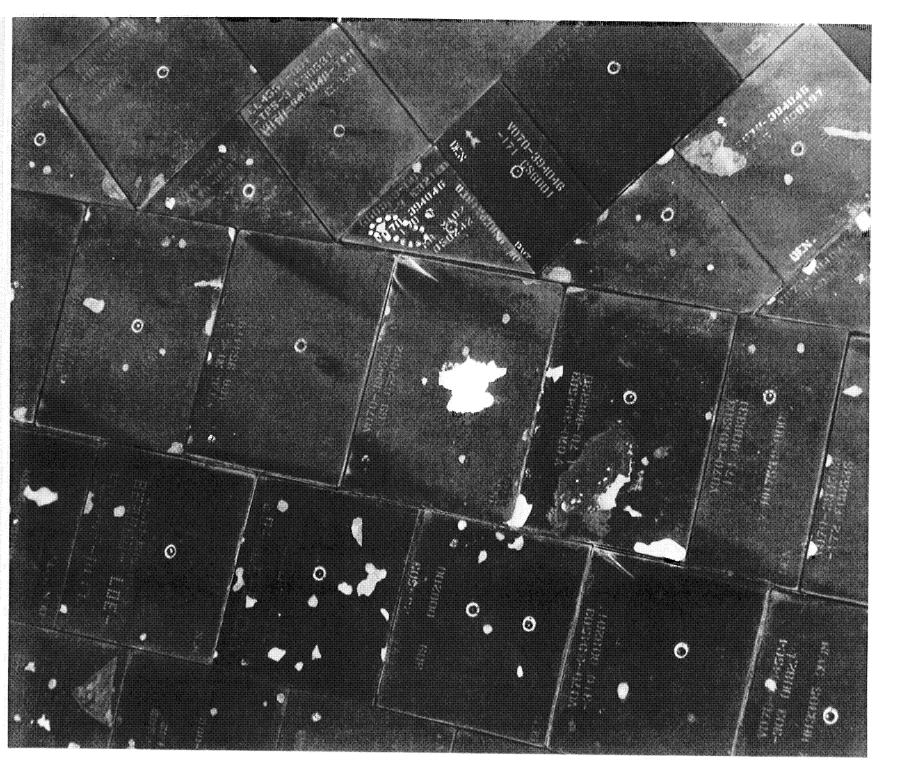


from the LH OMS pod tiles. No damage to surface coating material occurred. surface Gap filler protrudes adjacent tiles



ET/ORB the LH2 impacts of ice aft by i surface tile damage is typically caused 202 Cluster of lower umbilical

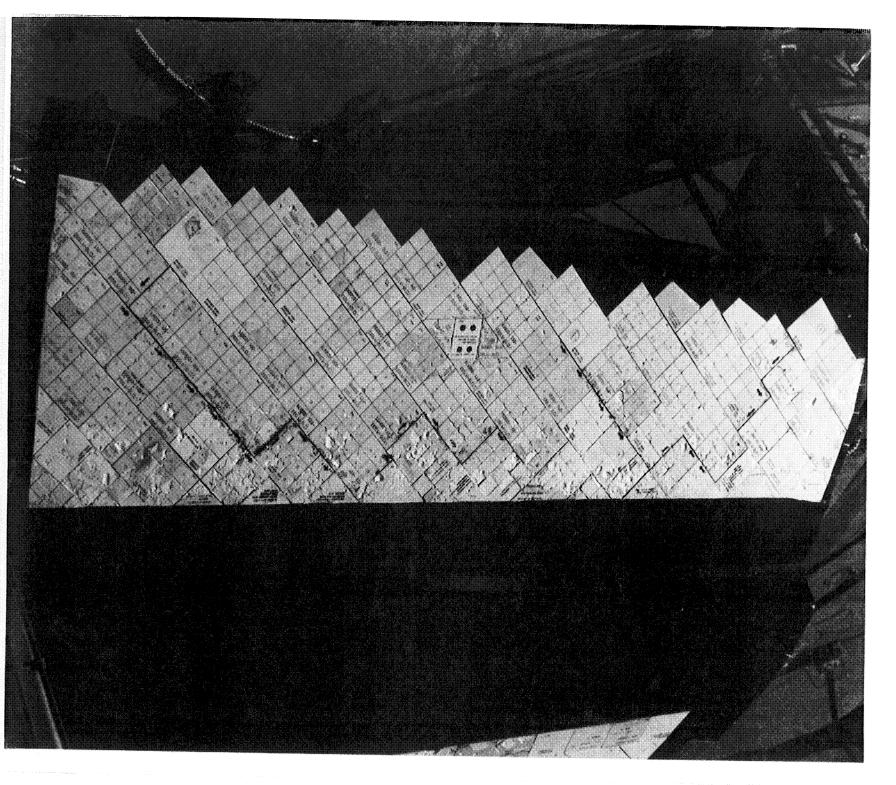
q' · · · · · · · · · · · · · · · · · · ·	*	



Typical impact-type damage to tile surface. Note numerous repairs to small areas in surrounding tiles.

ONGINAL PAGE





LH outboard elevon upper surface tiles have lost material, hich is visible in launch films falling during SSME ignition 204 which is visible

*	· · · · · · · · · · · · · · · · · · ·		
		w.	

from RH outboard elevon was ling from the vehicle tile screed repair missing from visible in launch films falling 205 White

**			*	¥	
	,				

Post flight examination of EO-1 attach point revealed compressive loading damage to RH Y-Y centering bolt 206

ORIGINAL PAGE COLOR PHOTOGRAPH

	<b>*</b>			*	×			
		•						
						100, 11		

### SAMPLE LAB REPORTS DEBRIS 10.0

during Ames-Dryden Flight Research Facility, California. The 13 submitted samples consisted of 8 orbiter window wipes, 1 tile sample, and 4 samples from the ET/ORB umbilical area. The samples were analyzed by the NASA KSC Microchemical Analysis Branch (MAB) for material composition and comparison to known STS materials. submitted samples samples were Branch (MAB) in the appended MAB provided by Orbiter OV-102 provided at Orbiter debris assessment California. The 13 s sis is shown analyses are obtained from summaries debris elemental analysis and Were post-landing location in the following sambles sambles Debris 13 specific STS-32R οĘ reports.

# Orbiter Windows

analysis indicates the presence chemical following materials: window wipe οĘ Results

- metal and Aluminum H 24 B 4 B 6
- nd copper and salt dust Rust, Paint
- Muscovite
- insulation and Tile
- Organics

# analysis provides the following correlations: Debris

- the landing quantity this ţО common in concern are copper metals debris Ŋ and not Aluminum are (micrometer) and
  - salt and dust is probably an SRB BSM residue; site products. Rust landing
- facility/ground and element flightდ დ equipment coating. is used Paint support
- site landing naturally-occurring Ŋ .പ დ Muscovite product. 4
  - from Orbiter thermal protection are insulation and (TPS) Tile system
    - remains materials are probably insect/animal tile waterproofing. materials are and deposits, or Organic ဖ်

#### TILE ORBITER

analysi chemical following materials: and the sampled of the Was site the presence damage One tile revealed

- Aluminum
- fibers/bundle) (synthetic Carbon H 26 8 4 C
  - Titanium
- fibers Silica tile
  - traces Iron

correlations: following analysis provides the Debris

- residue 1. Aluminum is probably from SRB/BSM 2. Carbon appears to be the charrec
- whatever sulphur, οĘ silicon, contained trace silin to and impacted the tile, archromium, and chlorine. Carbon
- elements' ink; ne of the ORB-tile e the restant or DeSoto primer; ORB-t epoxy, Rustoleum topcoat Titanium could be the ET-FRL paint topcoat Sikkens coatings Hypalon,
  - thermal Orbiter fibers are probably tile protection system. Silica ₽ •
- paint are probably RTV residue or ET FRL traces Iron residue

# ORBITER WING RCC PANELS

18 and the splice panel suffiable to provide white 17 & Were The panels locations material for analysis. from the RCC sample RCC 77. not be removed the10 oĘ between cient None

# (LH-LH2) ET-ORBITER UMBILICAL

LH ET/ORBITER umbilical the following materials: Rust and dust
Calcite from samples of the al analysis revealed the Chemical

- H 2 W 4 B 2 F
- glas and insulation Black tile
  - Alpha-quartz
- foam Urethane
  - Microballoon
- Organics

correlations: following analysis provides the

- exhaust SRB/BSM probably a n e particles Aluminum residue.
- dust BSM residue origin, SRB is probably of Rust
- thermal Orbiter naturally-occurring environmental origin.
  3. Calcite is a natural landing site product
  4. Black tile and insulation glass are of O protection system origin.
- earth the purest forms of the oŧ one and tile base ب ي Alpha-quartz silica mineral
  - elements. base component. a bond/sealant or RTV is used as
- umbilical ablators. thesed as a bond/sealant on the flight foam is a closeout material for the oon is a component of ET/SRB ablatc Microballoon is a component Urethane ъ 8
- deposits and remains insect animal may be waterproofing. 9. or tile

# (RH-LOX) ET-ORBITER UMBILICAL

umbilical the RH ET/ORBITER materials from sambles following οĘ the al analysis revealed the Chemical (LOX)

- dust and Rust H 0 6 4 5
- foam Urethane
  - Microballoon
    - Organics

analysis provides the following correlations Debris

- σĘ ٦. ي dust origin, 1. Rust is probably of SRB BSM residue originaturally-occurring environmental origin.

  2. Calcite is a natural landing site product.

  3. Urethane foam is a closeout material for t

  4. Microballoon is a component of ET/SRB abla

  5. Organics may be animal or insect remains
- material for the umbilical of ET/SRB ablators.
- deposit and waterproofing. tile or

### Conclusions

analysis is. This that ng damage from debrichenical analysis t analysis debris by the evidenced minimizing the samples. be true by დ დ in performed on post-flight mission, successful t 0 shown STS-32R report, was is also sho

indicated thermal protection that results sampling provided residue, paint, t site products. exposure to SRB BSM rematerials, and landing Orbiter window

protection carbon tile thermal fibrous synthetic indicated only charred tile sample ๙ and the damage site. system material The Orbiter

sample panels provided no The Orbiter wing RCC

οŧ a variety demonstrat area continues to entrap However, none for this mission umbilical particles. The ET/Orbiter concern. debris debris

charred impacts debris he a t 0 orbital origin. found evidence of Was of unknown debris impact sample
fibrous material This mission provided no The tile impact sample synthetic

#### BUILDING BRANCH LOAL ANALYSIS 1 1-1, ROOM 1274, O&C E NASA/KSC FEBRUARY 1 MICROCHEMICAL DM-MSL-1,

2 -10 0

32R,

STS-

from

Ø

Debri

and

Wipes

Window

SUBJECT

0043-90 MCB NO: REQUEST LABORATORY

Requirement Team Ø Debri Intercenter DOCUMENTATION RELATED

#### FOREWORD 0. ---

- -080-22, -MSD-Speece/NASA/TV Ŀ В. REQUESTER 1.1
- and Were particles California The DFRF, REQUESTER'S SAMPLE DESCRIPTION: removed from OV-102, STS-32R, D were identified as follows: REQUESTER'S 5.

06-005 06-005 06-005 06-005 06-005 06-005 S E S E S 55022 55022 55022 55022 55022 55022 55022 #####1, #####3, ##55, Windows
#1. Window
#2. Window
#4. Window
#5. Window
#6. Window Window #########

#### 1/22/90 1/22/90Door Door ET L/HR/HOV-102, OV-102, Tape #9.

#### Cavities Hand Umbilical Right cal C Left ٠Ĥ Umbil: #11. #12.

Hand Umbilical

- and identification Ø chemical/material
  inown STS material to known REQUESTED: Perform compare results to }  $^{\circ}$
- AND RESULTS ANALYSIS CHEMICAL 0. N

#### Procedures 2.1

optical microscopy (EDS) and electron spectrometry of The samples were analyzed by means (OM), infrared spectrometry (IRS), microprobe with energy dispersive s

#### Results 2 2

The particulates were classified into components on the basis of color and texture by OM. The classified components from all samples are listed in Table 1 with the possible identification of each component and elemental analysis. 2.2.1

Table 1

Component	DO 80 CT : 10	Elemental Analysis by EDS*	sis by EDS*
QI	Ident.	jor	Minor
1. Metallics Cu,Al 2. Black Mtls Rust,Dust, 3. Wht-Grey Mtls Si-Al Rich 4. White Powder Calcite 5. Black Dense Tile 6. Black Sphere C-Steel Spl 7. White Clear Alpha-Quark 8. LgtBrn Flake Muscovite 10. Yellow Mtls Paints 11. Red Mtls RTV	Cu, Al Rust, Dust, Salt Si-Al Rich Calcite Tile C-Steel Sphere Alpha-Quartz Muscovite InsulationGlass Paints	Cu, Al Fe, Si, Al, Ca, S, K P, Cl, Mg Si, Al Si Si Fe Si Si Si Fe, K, Si, Al Si, Ti, Cr, S Fe, K, S	P,Cl,Mg Na,Cl,K Mn,Ti,Mg Fe,K,S

component each estimated amounts of number. 2 lists s sample versus Table 2.2.2

 $^{\circ}$ Table

Sample No. Amt. Sample	#	#	% #	4	# 10	9#	#	ω #	     6   #	0	<del> </del>	+ 
1.Metallics	2(Cu)	×		×	T(Cu)	×	T(Cu)	Ĭ×	1(A1)	i ×	i ×	i
2.Dust or Rust	15	10	A1)	H 0	2 0		4. (	10	ស ;	30	×	×
7 7 7	- ×			ν γ ×	ν ο ⋈	×	ر بر د	ر ک ×	7 X	X 9	××	××
5.Tile	×	×	×	×	×	×	×	×		×	×	: ×
phe	×	×	×	×	×	×	×	×	<del></del>	×	×	×
	×	×	×	×	×	×	×	×	C1	×	×	×
8.Muscovite	10	00	×	×	₽	×	E	H	×	×	×	1- 1/2
9.Tile or	H	<u>-</u>	×	E	×	×	E	×	30	54	×	 )서
Insulation												
10.Paints,	×	E	×	×	×	×	×	×	×	×	×	×
Primer												
11.RTV	×	×	×	×	×	×	×	×	H	×	×	×
12.Foam	×	×	×	×	×	×	×	×	30	10	100	100
13.Microballoon	×	×	×	×	×	×	×	×	H	E		×
14.Organics Particle Size	7	7	<del></del>	H	E	86	E	H	ω	H	×	×
Size, um	1-80	150	1-80	1-1	1-30	1-170	1-150	1-50	1-500	1-300		1

Not detected

Cu-Metals Trace Al-, C X: T: (Cu): and (A1)

in Figures 1, 2, 3, and 4 are EDS spectra of light-brown flakes, white materials, black materials in sample #6, and black materials sample #8, respectively.  $\sim$ 2.5

#### CONCLUSIONS 3.0

#### #8) THROUGH #1 (SAMPLE WINDOWS 3.1

- were contained The sample numbers 1, 3, 5, 7, and 9 contaitrace amounts of metallics. The metallics and Al-metals. sample numbers cncomposed of The 3.1.1
- Si-Û til οf and dust. All samples contained large amounts Al rich high temperature materials. These materials might be formed from the thermal samples contained black-colored rust
  .. All samples contained large amount upon reentry A11 . 3.1
- contained ω and The sample numbers 1, 2, 5, 7, a muscovite [KAl2(AlSi3010)(OH)2]. 3.1.3

- trace glass contained or tile c glass and 1, 2, 4, 5 insulation numbers either i The sample fibers. 4. 3.1
- οf amounts trace contained ~ number The sample paints. ឃុំ 3.1
- the organic amounts of organics. to small a due contained analyzed All samples were not ana samples. All 3.1.6

#### #10) AND 6# (SAMPLE TAPES 3.2

- rust, lass dust, glas The sample #9 contained Al-particles, ducalcite, black tiles, C-steel spheres, Alpha-Quartz (Alpha-SiO2), insulation glfiber, RTV, urethane foam, microballoon organics. 3.2.1
- rust, and The sample #10 was composed of dust, calcite, urethane foam, microballoon #10 organics. . 7

### CAL CAVITIES 3.3

- composed were 12 and foam. ဌ urethane numbers sample rely of entirely Both 3.3.1
- glass fibers appeared to be originated from TPS and the rest of materials appeared to be originated from TPS and the natural environment 3.4
- of in the range The particle sizes were estimated to be 1 to 500 micrometers. 3.5

CHEMIST:

H

APPROVED:

BRN FLAKES,0043-90 L87 Figure 1.



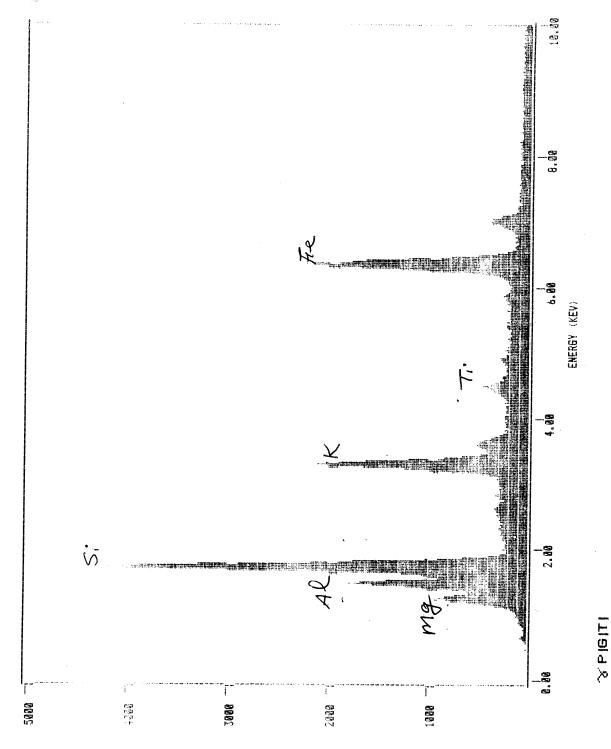


Figure 2.

BLK MTLS, 495-89 SPECTRUM LABEL

MTLS,4,0043-90 WHITE

SPECTRUM FILE NAME

19989 H

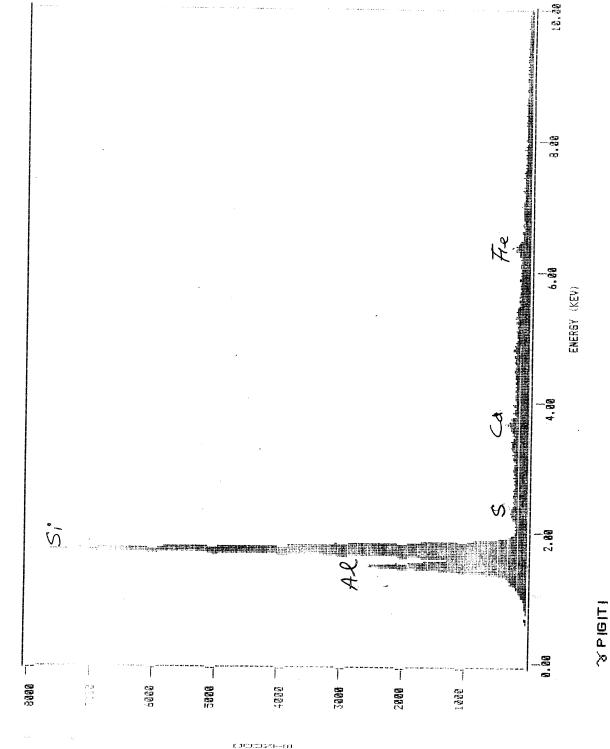


Figure 3. BLK MTLS, 6,0043-89

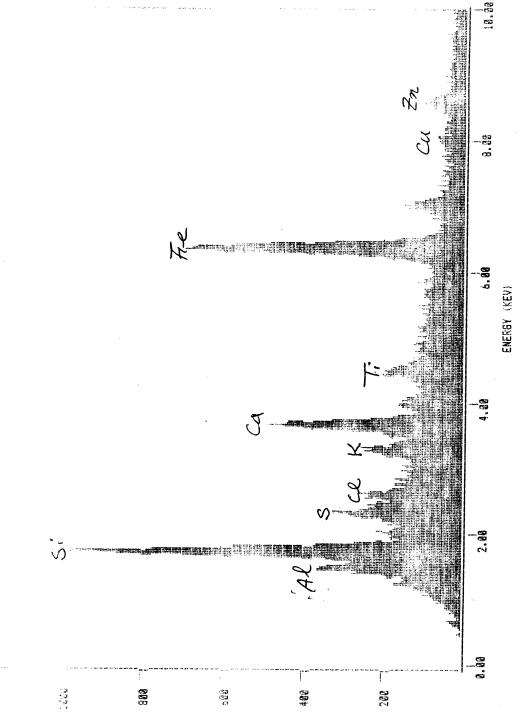
SPECTRUM LABEL

BLK MTLS, 495-89

250

SPECTRUM FILE NAME

-908) **Willi** 

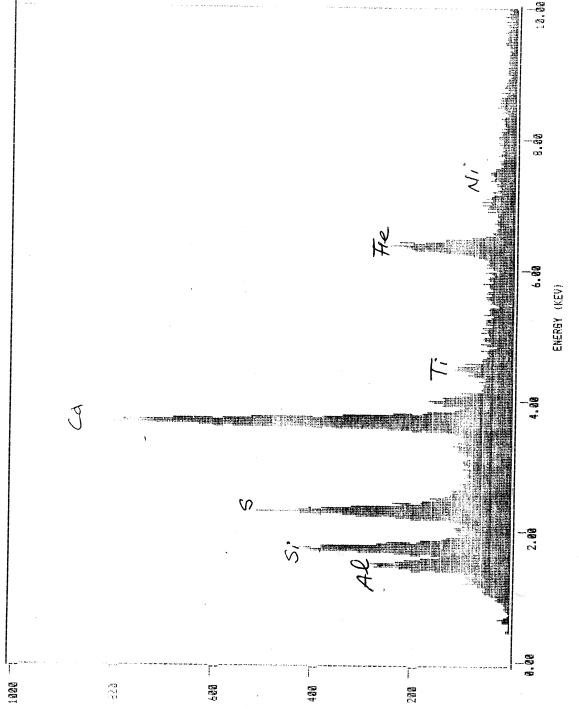


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#### MICROCHEMICAL ANALYSIS BRANCH DM-MSL-1, ROOM 1274, O&C BUILDING NASA/KSC February 7, 1990

STS-32Rov-102, Site Damage Tile from Sample

LABORATORY REQUEST NO: MCB-0053-90

Requirement Team Debris Intercenter RELATED DOCUMENTATION

# 1.0 FOREWORD:

- Speece/TV-MSD-22/7-0806 R.F. REQUESTER
- 1.2 REQUESTER'S SAMPLE DESCRIPTION:

3-169 Calif tile VO70-394503-1, OV-102, DFRF, Ca e site, ti STS-32R, from tile damage
lower surface, 3 Sample f Orbiter

# 1.3 REQUESTED:

analysis identification STS materials. chemical/material to known results Perform compare

# 2.0 CHEMICAL ANALYSIS AND RESULTS:

- microscope (SEM) and analyzed by X-ray energy dispersive spectroscopy (EDS). EDS analysis provides a qualitative and semiquantitative analysis of all elements in the periodic table above boron (5). The method is sensitive relative electron require higher re 0 ° 4% above scanning elements if they are present above Light elements (below #9 in the have less sensitivity and require herentages for detection.  $\mathbf{p}_{\mathbf{Y}}$ examined was weight percentages (SEM) a Particulates table) have to most 2.1
- analyzed parts of the os are shown in optical photo 1, and larger are obviously black (and white) fragments c surface are shown in optical photo 2. were that samble Individual particles from the by EDS are shown in optical ph that ? 2
- indicated However analyses of 12 of the white particles shown in photo 1 indicated varying levels of aluminium, carbon the silica tile fibers. Some of these analumication of provided with this reconstruction. particulates were -black and the glassy white particulante silica (only silication) figures analyses the EDS 2.3

in maythis included appears i the this The EDS analysis of t gure 4. In addition with sulfur, but RTV ther particles found a fiber bund! e 3, (two n in the red RTV material (twee analyzed) that is often four The only other particles for fibers and a fiber hard. in figure 4. I to be carbon. traces s presented contains tra chlorine. ខ ٥f light residue. synthetic iron Were carbon it polarized lig fiber bundle trace chromium and particles tile resid to slight be due some

and white sides of the photo 2 indicated only of the black sides and particles shown in photon and oxygen peaks). analysis of t e surface part ica (silicon a EDS ana tile su silica 2.4

#### CONCLUSIONS: 3.0

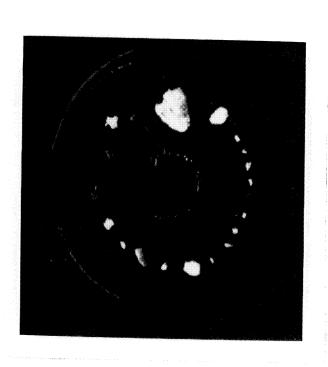
s of and varying levels to the silicon a These may be These may tile. to particles of this sample contained in titanium and carbon in addition the glass fiber tile material. residues of whatever impacted the t the Several parally aluminum, toxygen of oxygen o

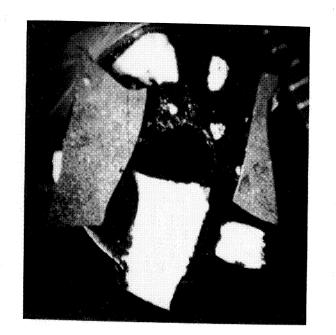
Stan CHEMIST:

APPROVED:

STATE IS TIME WOOD TO CRICINAL

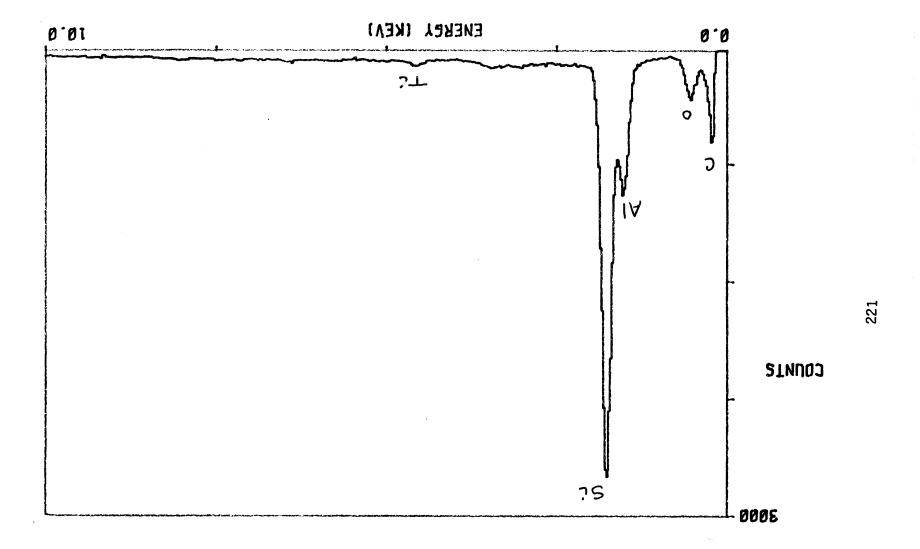
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			<b>建</b> 益 7.5.

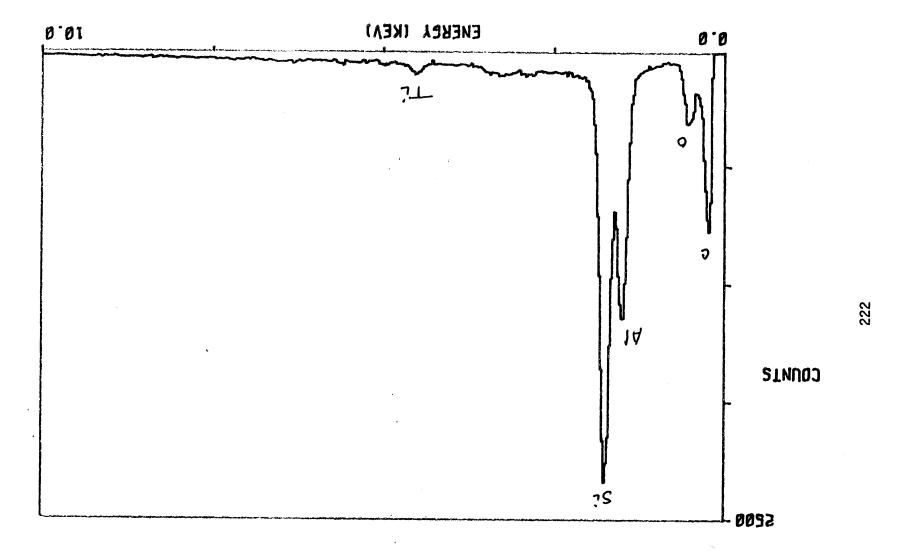




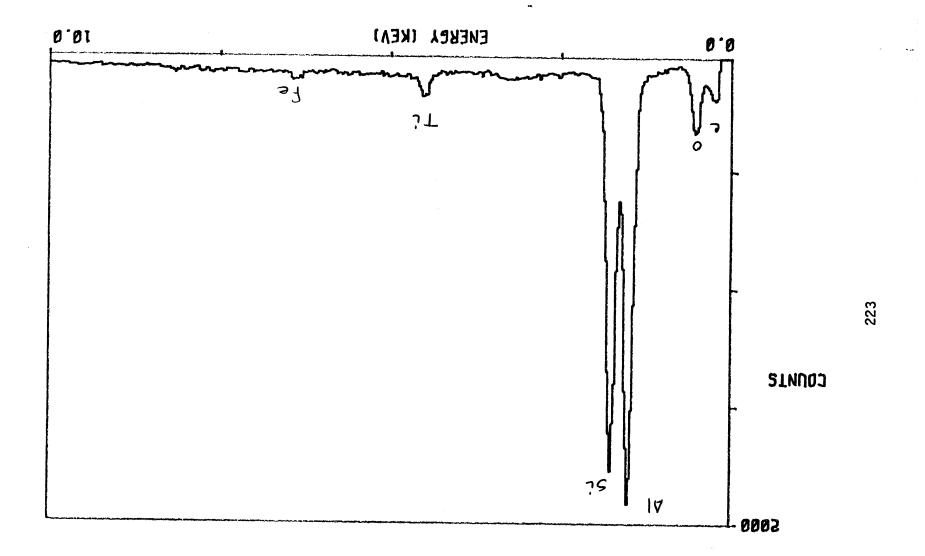


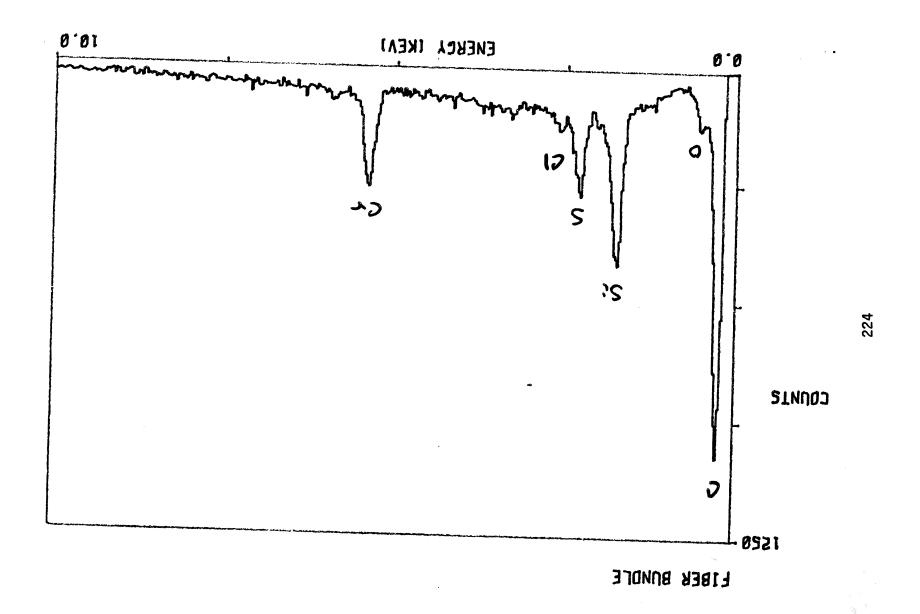
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#### ANOMALIES POST LAUNCH 11.0

Launch Post 20 inspections and film review, ved for STS-32R. Anomalies were observed for the debris 0 Based

# POST LAUNCH PAD INSPECTION 11.1

- from the Orbiter base heatshield Three Q-felt closeout plugs from were found on the pad after launch. Three
- found Were shim material shoe item 8) holddown post SRB, item 5; Two pieces of (Reference Film,
- repair elevon piece the forward outboard corner. (Reference Film, The tile Was A piece of tile 4"x3-3/8"x1/2" maximum thickness was ad A approximately 700 feet west of the FSS. The tile determined to be mostly an unrestricted 364 screed tile 197004-069. This tile is located on the RH the RH 197004-069. surface at 3. A piece on Pad A ap 4 upper from item
- revealed item sandboxes (Reference Film, item 1; SRB, the SRB holddown post o F following debris Inspection
- fragment metal
- frangible nut webs
- HOP
- o F one fragments, NSI cartridge, 1 metal fragment small (less than 1/2") fragment; a piece of frangible nut web 9 11 12 11
- frangible nut web, ۲. ق #5 HDP
  - fragment cartridge metal NSI Н 1 piece of fragment, nut threads, with
    - fragment metal HOP
    - None \*\*<del>\*</del>
- ហ cartridge fragment with threads, fragments NSI metal

#### FILM REVIEW 11.2

- foot Thirteen pieces s fell from the er liftoff. One after fragments, cartridge fragment, before the aft skirt shortly as the cleared the holddown post doghouse blast cover. Thirtee of frangible nut and/or NSI cartridge fragments fell LH SRB aft skirt HDP #5 stud hole shortly after lift object fell from the LH SRB HDP #7 stud hole short liftoff. Two objects, most likely frangible nut/NSI friell from the LH SRB HDP #8 aft skirt stud hole as the item 7) item 4; SRB, possibly an NSI #3 stud hole just an NSI (Reference Pad, object, SRB HDP the RH small ascended. from
- surface coating material from aft faces of the RCS stingers shaken loose by SSME ignition acoustics. few small pieces of tile son the base heatshield and few 2. A tiles Were

- evons. This Inspection elevons. tiles near RCC panel ICe the RH the during fell between tile shim fell bashim identified surface the lower orange Grande 's tile GSE from protruding may be
- wing most į. S Orbiter object item 3) appears to originate from the (end of the roll maneuver. The 4. A white object appears to originate from the tip area near the end of the roll maneuver. The likely the white tile fragment. (Reference Pad,
- shoe of HDP #2 As the vehicle shoe. the into shim was debonded from the upward by the SRB aft skirt foot. to rise, this piece fell back back skb, itc item rise, th of Epon (Reference Pad, t 0 piece pulled continued and

# SRB POST FLIGHT/RETRIEVAL INSPECTION

- debonds near debond. exhibited 5 divot acreage 2-inch frustum was missing no TPS but neads and one 1.75-inch diameter exhibited 23 debonds and one 2-: over bolt heads frustum The RH 275
- and LH forward RSS antenna phenolic plate on both RH skirt was delaminated/missing. **7** The
- location delamina-3. The RH forward field joint had a 1.5-inch diameter of tion within the cork material at the 190 degree radial 2.5 inches aft of the forward edge.
- 4. A bolt head on one of the RH SRB IEA covers was missing
- protective domes were missing from bolt of the RH SRB kick ring at 260 degrees strate showed signs of heating prior to protective substrate heads on the aft side and the uncovered subs thermal water impact. Two K5NA
- was 1" long by seal joint EPDM moisture 240 degrees (3.5" lo 1.25" deep). 6. The LH aft segment factory joint debonded on the leading edge at 240 d deep) and 200 degrees (3" long by 1.25"
- Debris Containment Assemblies spherical washers were displaced by frangible nut/NSI cartridge deb jammed by frangible n
  item 4; Film, item 1) plungers in the Several spherical (Reference Pad, three plungers were were seated. Only
- A 15"x3.5" piece of shim was missing from the inboard holddown post #4 aft skirt foot prior to water imp ference Pad, item 2; Film, item 5) (Reference Pad, item 2;

# 11.4 ORBITER POST LANDING INSPECTION

- pyro connector backshells, as evidenced ordnance device spring housings. The RH thad been bent on STS-34, showed signs The RH contact t 0 sufficiently LH and RH bulkhead pyro connector becratch marks on the ordnance device centering bolt, which had been bent forward rotated compressive loading. had mechanism 五0-1 1. E PY a of
- tile (V070-292110-005-004) missing. đ The corner (1-1/2"x 1-1/2") of the left side of the rudder was ono 6
- of section aft LH 3. An 8"x2" section of FRSI blanket on the the payload bay door was loose (peeled back).

NACE Agrantics and Space Agrangiation	Report Documentation	on Page
1. Report No. TM 102787	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Debris/Ice/TPS Ass Analysis of Shutt	Subtitle Debris/Ice/TPS Assessment and Photographic Analysis of Shuttle Mission STS-32R	5. Report Date i.c. March 1990 6. Performing Organization Code
7. Author(s) Charles G. Stevenson Gregory N. Katnik Scott A. Higginbotham	son tham	8. Performing Organization Report No.
9. Performing Organization Name and Address NASA External Tank Mechanical Mail Code: TV-MSD-22 Kennedy Space Center, F1	nd Address Mechanical Systems Division -MSD-22 Center, Florida 32899	 
12. Sponsoring Agency Name and Address		13. Type of Report and Period Covered 14. Sponsoring Agency Code
15. Supplementary Notes		
A Debris/ for Space elements e frost con computer p cryogenic High spec sources ar anomalies. photograph the Space	A Debris/Ice/TPS assessment and photographic analysis was cond for Space Shuttle Mission STS-32R. Debris inspections of the felements and launch pad are performed before and after launch. frost conditions on the External Tank are assessed by the use computer programs, nomographs, and infrared scanner data during cryogenic loading of the vehicle followed by on-pad visual instants speed photography is analyzed after launch to identify ican sources and evaluate potential vehicle damage and/or in-flight anomalies. This report documents the debris/ice/TPS conditions photographic analysis of Mission STS-32R, and their overall efter Space Shuttle program.	Ice/TPS assessment and photographic analysis was conducted Shuttle Mission STS-32R. Debris inspections of the flight and launch pad are performed before and after launch. Ice/litions on the External Tank are assessed by the use of programs, nomographs, and infrared scanner data during loading of the vehicle followed by on-pad visual inspection. I photography is analyzed after launch to identify ice/debris of evaluate potential vehicle damage and/or in-flight. This report documents the debris/ice/TPS conditions and shuttle program.
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